DIFFUSION OF AGRICULTURAL INNOVATIONS IN UPPER GANGA-YAMUNA DOAB

THESIS

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IN

GEOGRAPHY

BY

FAZLUR RAHMAN

Under the Supervision of

Prof. Azimuddin Qureshi

DEPARTMENT OF GEOGRAPHY
ALIGARH MUSLIM UNIVERSITY
ALIGARH (INDIA)

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DEDICATED
TO MY
PARENTS

Prof. Azimuddin Qureshi
M.Sc., Ph.D.

Phone: 0091-571-400683 (Office)
DEPARTMENT OF GEOGRAPHY
ALIGARH MUSLIM UNIVERSITY
ALIGARH – 202002, INDIA

CERTIFICATE

This is to certify that **Mr. Fazlur Rahman** has pursued his research work and prepared the present thesis entitled "**Diffusion of Agricultural Innovations in Upper Ganga-Yamuna Doab**" under my supervision and guidance. This thesis is his original work and is being submitted to the Aligarh Muslim University Aligarh for the award of the degree of Doctor of Philosophy. .

(Prof. Azimuddin Qureshi)
Supervisor

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Fazlur Rahman

(FAZLUR RAHMAN)

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CHAPTER 1

INTRODUCTION

INTRODUCTION

1 The term innovation usually is meant to refer to something new in technology, method, idea or invention. Innovation is change over of new ideas, objects or practices from existing one by or constituents of social system. Innovation may show either slight modification significant replacement of ideas in vague. The 'idea' is the central element of an innovation, either in material form or behavioural form. For ideal result the innovation should be adopted both in terms of idea and form i.e., material or behavioural which ultimately felt by attaining intended consequences of an innovation.

2 Innovation refers to some new idea, method, or technology, and its diffusion means not only the spreading of the information over the entire area but also the adoption of the innovation. Nevertheless, the process of the spread of information is vital to the process of adoption, thus the entire diffusion process itself. The diffusion is the process in the course of which an innovation is adopted by those who had not adopted it earlier. In other words, diffusion is the process by which an innovation spreads within a social system. Innovation diffuses within a social system at group level and to individuals through its "adoption". Diffusion and adoption are complement to each other, thus they are closely interrelated Inspite of being distinct conceptually.

3 In agriculture the term "innovation" manifests a material form which include improved implements, high-yielding and disease-resistant seeds, chemical fertilizers and plant protection chemicals such as pesticides, fungicides, and herbicides.

4 Diffusion of Agricultural Innovations refers to the spread and implementation of new and improved agricultural practices over the existing one by the farmers in terms of use of HYV, pesticides,

fungicides, herbicides, mechanisation agricultural farming etc. The reflection of some innovation may be seen in behavioural form e.g., improved cultural practices. In other words we can say that diffusion of agricultural innovations means spread of adoption of improved agricultural practices.)

(5) (Innovations do vary in their diffusion rate; some diffuses at higher rate, while others at slight rate. An innovation which show only a slight modification of an existing idea or practice will obviously diffuse at a faster rate than the one which represents a significant modification over existing one. It is due to the fact that, in slight modification the society need not worry about the changing of whole existing setup or the major part of it. In case of significant modification there are problems for society to adopt new practices in which major part of existing practices is to be reinstalled.)

(6) (Some of the important traits of an innovation, which influence its rate of adoption, are: utility, compatibility, complexity, communicability and divisibility.)

(7) (Utility of an innovation refers to the degree to which it is perceived as useful and advantageous by farmers. Compatibility is the degree to which an innovation is perceived to be in conformity with the ideas, values and practices of a social system. Complexity refers to the relative difficulty to understand the nature and use of air innovation. Communicability is the degree to which the use and result of an innovation can be observed communicated to others. Divisibility refers to the degree to which an innovation can be tried out in a small scale before making the decision to adopt it.)

Most of these traits are a matter of perception to farmers rather than being inherent qualities of an innovation. Although the communicability or divisibility appears to be an inherent trait of an innovation, the utility, compatibility or complexity of an innovation depends on the of perception by farmers. The perceived qualities of an innovation vary for individual farmers and social systems.

8 Diffusion of agricultural innovations has a very strong bearing upon the agricultural efficiency and productivity in any region or area. Diffusion of agricultural innovations vary from one social system to another and also within the social system itself because of the way in which it is perceived is more important. At present all new ideas, practices and technology are geared to the improvement in agricultural efficiency (which is directly proportional to diffusion of innovation) more so in less developed countries of the world such as India. It has been proved beyond doubt by now that the technology of even the late 19th century would not have been able to provide sustenance to the present large
9 population of the world. There have been a number of innovations, which have brought about revolutionary changes in the agricultural productivity and efficiency all over the world. In this connection we can cite the example of India, where the diffusion has been rather slow, but at numerous instances, it has shown positive results.

10 Taking the case of mechanisation of farming operations, a tractor makes possible cultivation of wide spread areas more effectively in a much shorter period. In India major part of cultivable land left fallow in the form of culturable waste because of in efficiency of animal driven plough, however with the introduction of tractor, it has been brought under cultivation. Use of machinery for sowing, irrigation, harvesting, and separating grain from husk, has made commerce to the cropping of cereals like wheat. Use of power (mechanical or electrical) has made irrigation possible in many unirrigated areas.

11 More or equally important has been the result of diffusion of practices of using HYV, chemical fertilizers. This has been a major

factor in solving India's food problem to a greater extent. Many new varieties are better suited to the environmental conditions in various regions. Being adverse environmental suited varieties, the chances of its failures is reduced significantly. Chemical fertilizers have proven a boon, as our agriculture suffered a lot due to exhaustion of fertility under repeated and long continuous use. Fertilizers and irrigation facilities have made possible the practices of double and sometimes even multiple cropping in the areas where even a single crop would be at the mercy of weather elements.

12 Practices like contour bunding have made cultivation possible on slope. Innovations in the field of agricultural infra-structure have gone a long way in ensuring returns to the farmers and now a days there are arrangements for timely lifting of perishable commodities.

13 Thus a lot of loss, which used to be there as a result of non-lifting of products in time, has been made available due to diffusion of agricultural innovations. We thus, can say that diffusion of innovation has a direct positive bearing upon agricultural efficiency. As regards our own country, a lot has been done and we are reaping the benefits in the form of better efficiency and consequently increased production. However, Indian farmers are still very much tradition bound and need a lot of effort encouraging and coaxing them to adopt the new, may be equipment, a farming technique, a new seed or a new chemical fertilizer.

14 It takes time for an innovation to diffuse throughout a social system because all farmers in a community never adopt an innovation just after its introduction. There is always a variation among the members of a social system in the way they respond to an innovation i.e., idea or practice due to variation in nature and behaviour of different members within the society and among the societies.

15 The concept of diffusion of innovation forms an important aspect in geography, which is a model of time-space relationship. Not only Geographers are involved but sociologists, psychologists and economists are also paying much attention towards diffusion studies because it is having inter-disciplinary approach. The term "diffusion" generally refers to dispersion, spreading out or intermingling whereas scientifically it has more precise meaning (Hagget 1975)[1].Diffusion of innovation is not a quick process, it has two important elements the time and the space. The spatial diffusion help in innovation, emigration, alteration, change or spread of ideas occurring in human society. The transfer may be economic, social or psychological. The diffusion also implies the spatial redistribution of some components or activities, more often than not, emanating from one or more centres. There may also be some population growth in addition (Wilson and Kirkby, 1975)[2]

16 Development is an innovative process leading to the structural transformation of social system (Friedmann, 1969)[3], however, development is a state of mind which emphasize an individual to use natural resources for the benefit of the society (Misra, 1985)[4]. Innovation according to Friedmann (1969) is the successful introduction of ideas perceived as new, into a given social system. The diffusion of innovation involves directly the acceptance overtime of some specific idea or practice by individuals, groups or other adopting units (Berry, 1972).[5]

17 The diffusion studies in the very beginning were conducted by anthropologists, however, both sociologists and anthropologists have been interested for a long time. The later part of 19th century witnessed the establishment of the "diffusionist school" of thought in anthropology, opposing the "evolutionists" argument that each culture grew independently of others following identical evolutionary stages. The evolutionists were believers of "psychic

unity" of man contributed to this process of evolution of each culture followed by number of stages through independent inventions, discoveries of ideas, materials, and practices. 'diffusionists' countered the argument by stating that man was too uninventive to come up with same ideas and practices repeatedly. They were opined of that once an idea or practice invented in one culture, it spread from there to other cultures. Most of the innovations both in ideas and practices of culture are borrowed from other cultures rather than being invented by itself. Various diffusionists considered in different meanings, British diffusionists in early 20th century argued that most of the constituents of human civilizations were first invented in Egypt and later on diffused to other parts of the world. While German diffusionists stressed to the fact that all cultural elements of human society were not invented in only one part of world, but in different parts of world in different stages. German diffusionist its seem to be more systematic and objective than their British counterpart, but they could not provide empirical evidence to prove the given fact. The diffusionist view point of cultural development was rejected by latter day anthropologists but notion 'diffusion' continued to play an important role in anthropological theories of social and cultural change.

Anthropologists study both the inter-societal diffusion of cultural traits and complexes and process by which such traits and complexes diffuse within a social system. Ralph Linton[6], for example, observed that new items, cultural or material, are adopted on the basis of evaluation of their three characteristics; (i) utility, (ii) compatibility and (iii) prestige. Utility determines rate of diffusion. The next to which an idea or practice is simply a modification of existing one or totally foreign to the knowledge and experience of the adopter will also determine whether or not it will be accepted. An idea or practice is also sometimes accepted and adopted because it enhances the status of the adopter within his social system.

18 Barnet[7] identified eight traits, which influence the acceptance of a novelty within a social system: compatibility, efficiency, advantage, prestige, pleasure, wastery, penalty and cost.

19 Till 1950s diffusion studies could not get serious attention from Sociologists, Albeit Gabriel Trade and F. Stuart Chapin[8] were first to show that the adoption of a new idea within a social system follows an S-shaped growth curve, and a number of other scholars attempted to trace the diffusion of single innovation like postage stamps, city manager plan government, and political attitudes, over a geographic area in the late 1920s and 1930s by using the secondary sources of data. Their interest in such case was to observe the "change within social system as well as to different social systems" in the adoption process by which an "individual decides to adopt or reject" or upon the process by which "an individual decides to adopt".

In the last four decades principal research activities of rural sociologists have been 'diffusion studies'. Rural sociology is said to be produced largest number of diffusion studies and is continued to contribute to diffusion studies. In 1920s U.S. Department of Agriculture decided to evaluate the process of their programme of improved farming practices among farmers i.e., diffusion of agricultural innovations. Bryce Ryan and Neal Gross[9] were the first scientists to get the greatest attention from social scientists regarding their research on the diffusion of hybrid seed corn in two Iowa communities. The findings of this study showed for the first time that adoption of innovations by farmers involved a combination of several processes. The process of individual decision making by a farmer to adopt or reject a practice, and of diffusion of an innovation over time through a social system are closely inter related. Since 1950s most of the diffusion studies have been inspired by the study of Ryan and Gross. The number of rural sociological researches on diffusion of innovation grew rapidly in U.S. during 1950s and 1960s, which pave the way for other similar studies in USA.

20 A review of 468 studies on the diffusion of agricultural conducted until 1967 have shown that the majority of these studies were conducted in North America, especially in United States, followed by Europe and Asia. Of the 46 studies conducted in Asia until 1967, almost 70 percent were made in India.

Early 1960s witnessed the appearance of diffusion studies in India for the first time. Most of these studies were conducted either by rural sociologists or specialists in agricultural extension, many of whom received their training in the U.S. Their studies dealt primarily with the diffusion of innovations and adoption of agricultural innovations. 21 With humble beginning in the early 1960s, the diffusion studies grew rapidly between 1965 and 1974. There was however, a significant decline in the number of such studies in between 1975 and 1979, and they came down almost to a trickle in 1985 to 1990.

22 The diffusion studies in India have been mostly in agricultural colleges and universities, state departments of agriculture, and research institutes. The findings of these studies are expected to assist extension agencies in encouraging farmers to adopt improved farming practices.

Another interesting feature of tradition of diffusion research in India is that a great majority of diffusion studies have been conducted by agricultural extension educationists rather than by rural sociologists. Indeed, most 'rural sociologists' in India are principally extension educationists with some back ground in sociology or rural sociology. The traditions of rural sociology and agricultural extension education are intimately related in India that it is often difficult to distinguish one from the other. Indeed, the Indian Journal of Extension Education is the single most important outlet for the publication of articles on research on diffusion of agricultural innovations in India.

23 Torsten Hagerstrand (1952)[10] was the first to demonstrate the idea of diffusion of agricultural innovations. He figured six components in the process of diffusion i.e., (i) area, (ii) time, (iii) item, (iv) origin, (v) destination and (vi) path.

24 Area according to him, the environment or space in which the process takes place may be uniform or highly marked off. Time is exhibitive of the stages by which innovation proceeds. Item is the component to be dispersed. Other three components are absolutely spatial elements. Origin refers to the source from where innovations begin and destinations are the points, which are the recipients in the process. Eventually, path is the footmark or route followed in the diffusion process. Hence, the path is of great value which apprises the diffusion waves.

25 An assured innovation can have more acknowledgements from human being in the comparison of others. So, the process of acceptors depends upon the significance of an innovation. They may be marked out five vital components of communication (i) information source, (ii) transmitter, (iii) channel, (iv) receiver and (v) destination (Shanon and Weaver, 1949)[11].

Any institution or agent may act as information source. Transmitter is the one who transmits the message to the receiver. It should be efficient enough to that the message does not vary in its vital components, design and thoughts. Channel is the medium used to transmit a message to the receiver whereas the receiver is the individual who attains delivery of the message or concept of innovation and works as mediator. At times, transmitter acts as a receiver also. Destination means the individual or clusters in an area who accept a special innovation.

Another important element related to diffusion of innovation is social system, as the process of adoption depends much on social system prevailing in a society. In a conservative and accustomed society, innovation takes place gradually, while in an advanced society, which has fair amount of literate, and economically sound population, the faster will be the rate of diffusion of innovations as compared to other.

The two significant elements of spatial systems are physical distance and functional distance. It is perceived that interaction among individuals as well as the diffusion of innovation are spatially hampered. Hence, the presumption: contact or diffusion goes on decreasing with increasing distances. True, the information extends out from originating source in such a way that the adoption of item of information is more likely to occur in the immediate vicinity as compared to others having the same information at a distance (Llyod and Dicken, 1972)[12].

The time is also a significant element concerning the process of innovation. Researchers have observed that in an initial stage there are only few adopters and their number goes on argumenting through time. It, however, decreases after achieving a level of saturation, the innovation or information so assumes spatial logistic curve. Contextually, Hagerstrand(1952) has diagnosed three classes of the population i.e., (i) non knowers, (ii) knowers but not adopters and (iii) adopters with respect to an item of information.

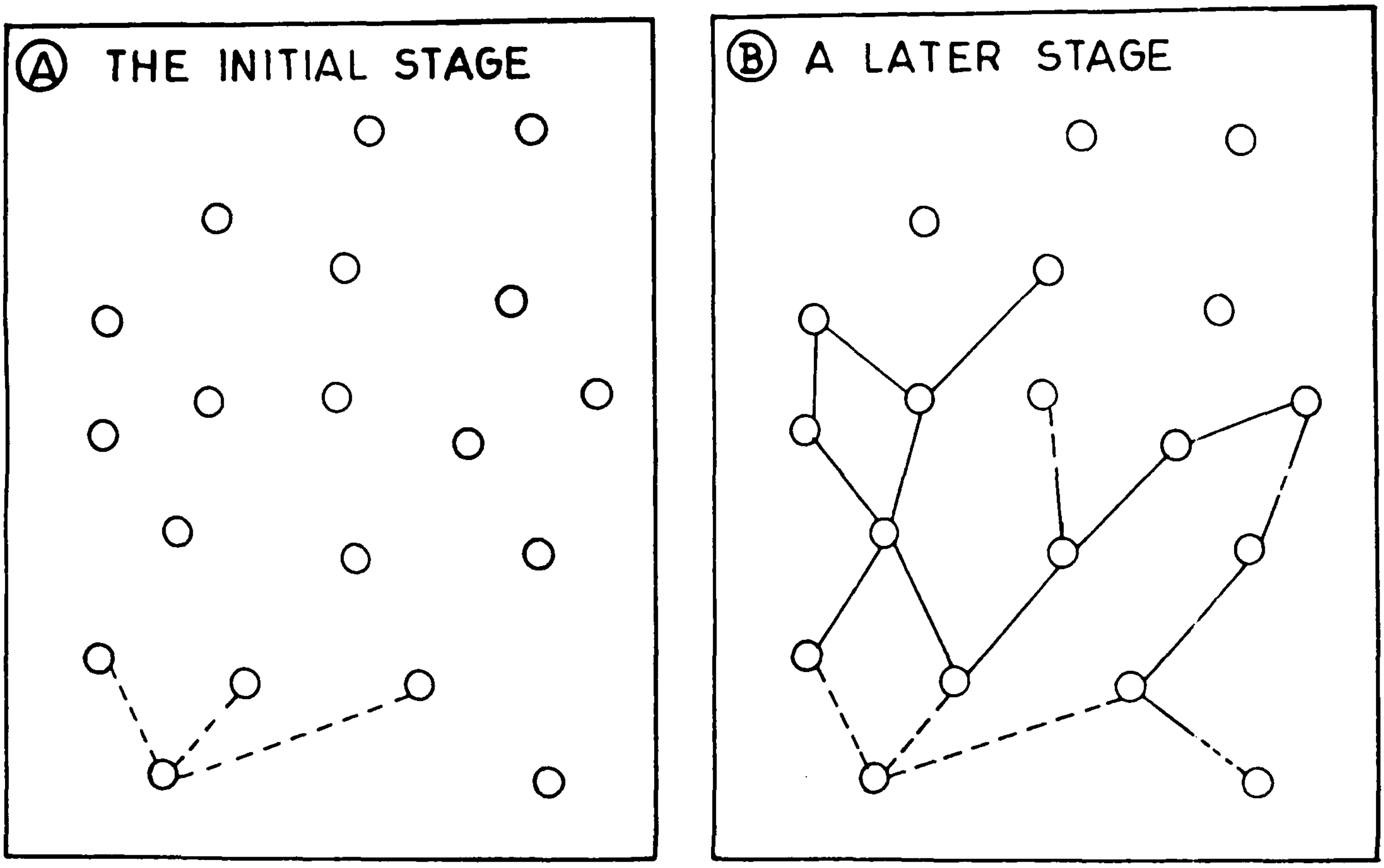
Resistance acts as significant agent of checking the adoption. A few variables which effect resistance are age, social status, financial position, mental ability or cosmopolitan attitude and group norms (Brown 1968)[13] Figure. 1.1.

26 Map showing diffusion of innovation marked with two kinds of locational patterns (Cox 1972)[14]. These are spatial trend and inversion. The dates of innovation on the one hand develop with distance from some site or sites and on the other, these do not develop with distance from site or sites at a point or line. Very absolute differentiation is there, between the two, because in most cases spatial diffusion maps explain links with the elements. Similarly, a composite or ambiguous pattern on maps appears to be confusing and ill defined. Thus necessitates filters to break off signals from noise (Gould, 1969)[15]. Diffusion may be of mononuclear or polynuclear type depending whether the originating source diffusion is single or multiple.

27 Hagerstrand (1952) Figure1.2 derived a four-stage model to explain the passage of what he named innovation waves more popularly called diffusion waves. From maps of the diffusion of several innovation ranging from bus routes to agricultural techniques in Sweden he drew a series of cross-sections to present the wave profile at different points of time (t_1, t_2, t_3, --- t_n)) He identified diffusion profiles characterised with four stages in the course of an innovation through an area;

28 A. **The Primary Stage**: This stage marks the beginning of the diffusion process, which is apparent by the system of the centres of the adoption.

29 B. **The Diffusion Stage**: It signals the start of the actual spread process in which diffusion being transmitted and a network of centres of innovation being raised up even in the remote areas.



Expansion Diffusion (Adapted from Brown, 1968)

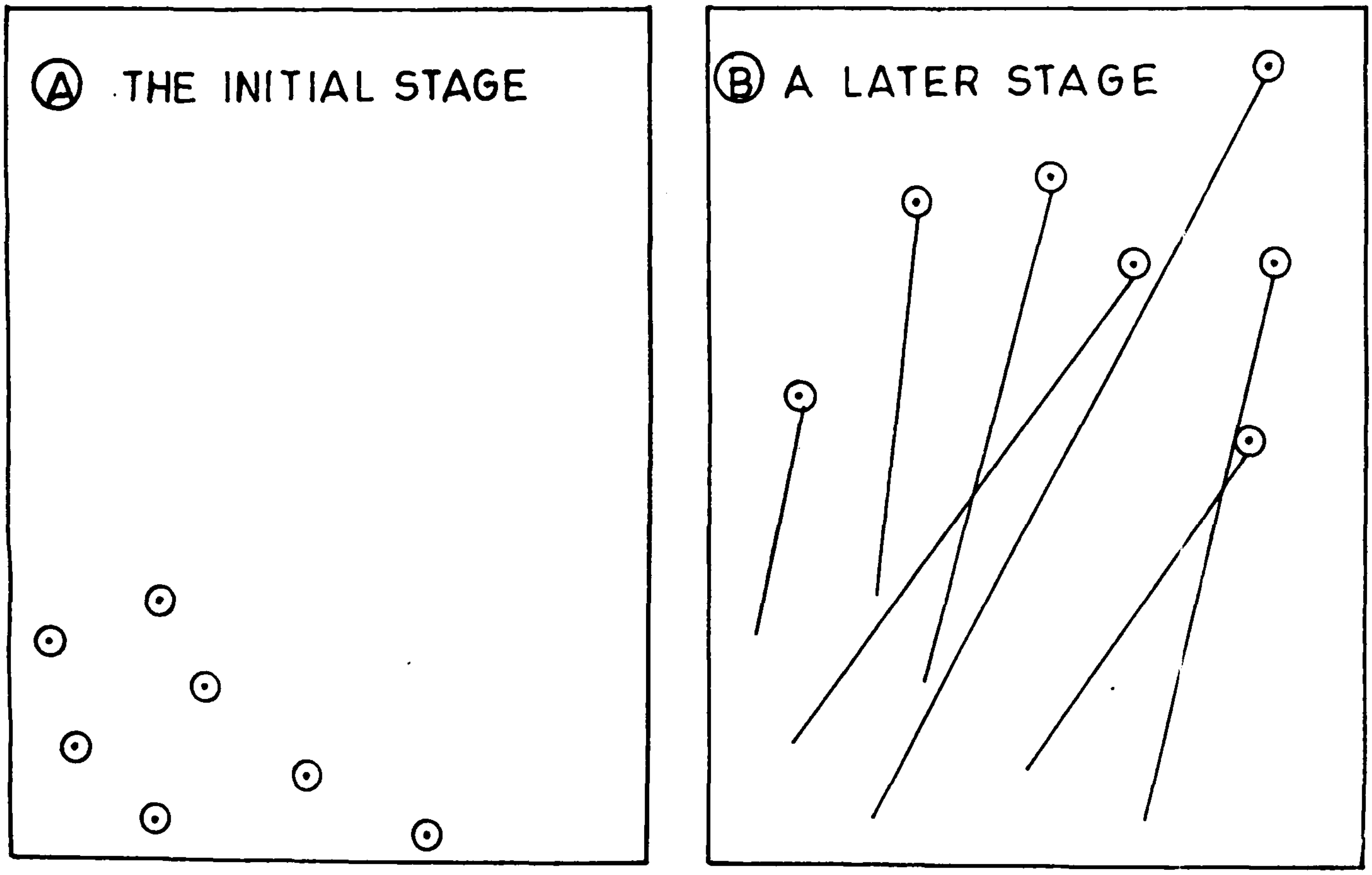


Fig. 1.1

I

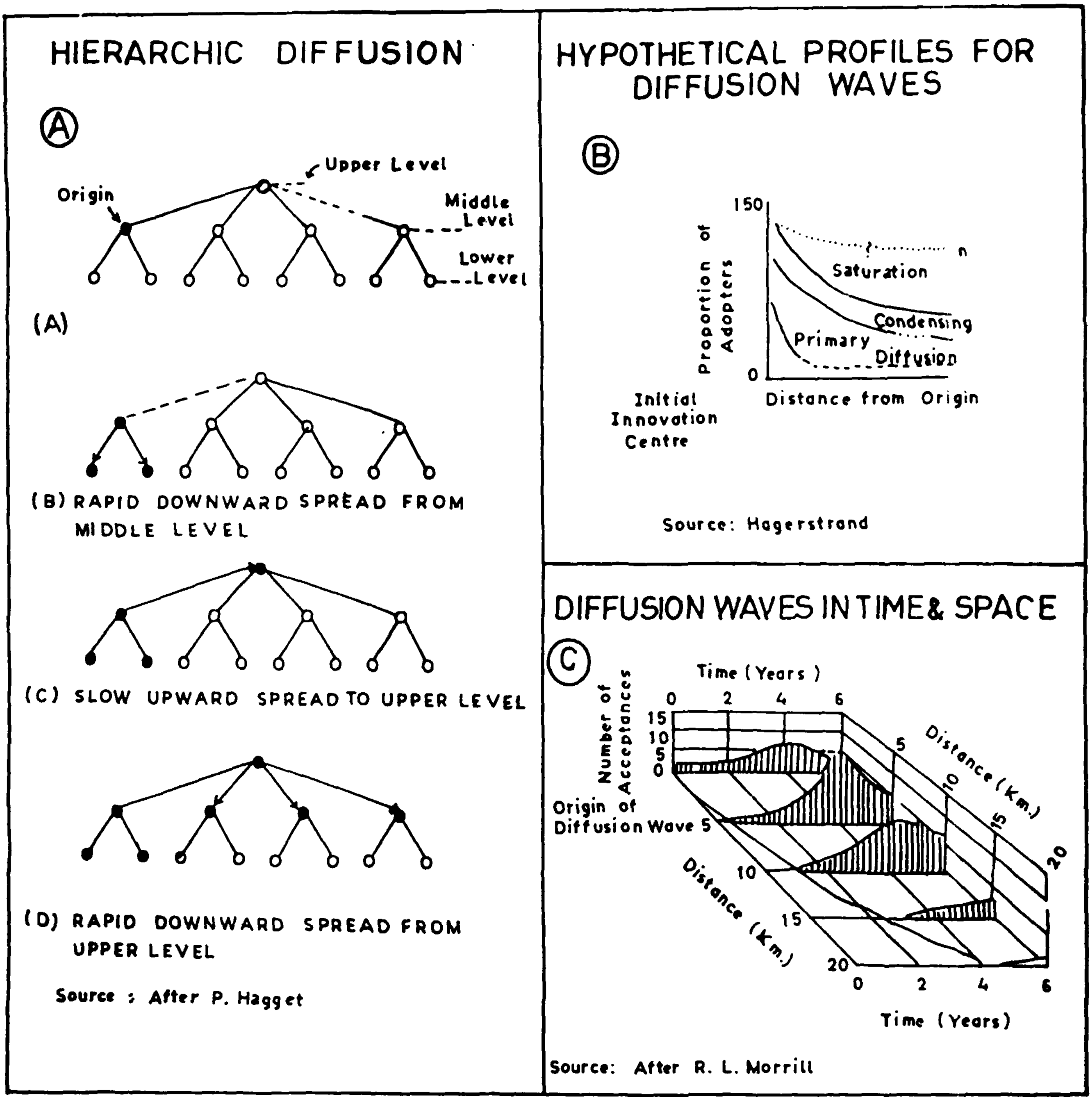

HIERARCHIC DIFFUSION
A
Upper Level
Origin
Middle Level
Lower Level
(A)
(B) RAPID DOWNWARD SPREAD FROM MIDDLE LEVEL
(C) SLOW UPWARD SPREAD TO UPPER LEVEL
(D) RAPID DOWNWARD SPREAD FROM UPPER LEVEL
Source : After P. Hagget
HYPOTHETICAL PROFILES FOR DIFFUSION WAVES
B
150
Proportion of Adopters
Saturation
Condensing
Primary
Diffusion
0
Initial Innovation Centre
Distance from Origin
Source: Hagerstrand
DIFFUSION WAVES IN TIME & SPACE
C
Time (Years)
Number of Acceptances
Origin of Diffusion Wave
Distance (Km.)
Time (Years)
Source: After R. L. Morrill

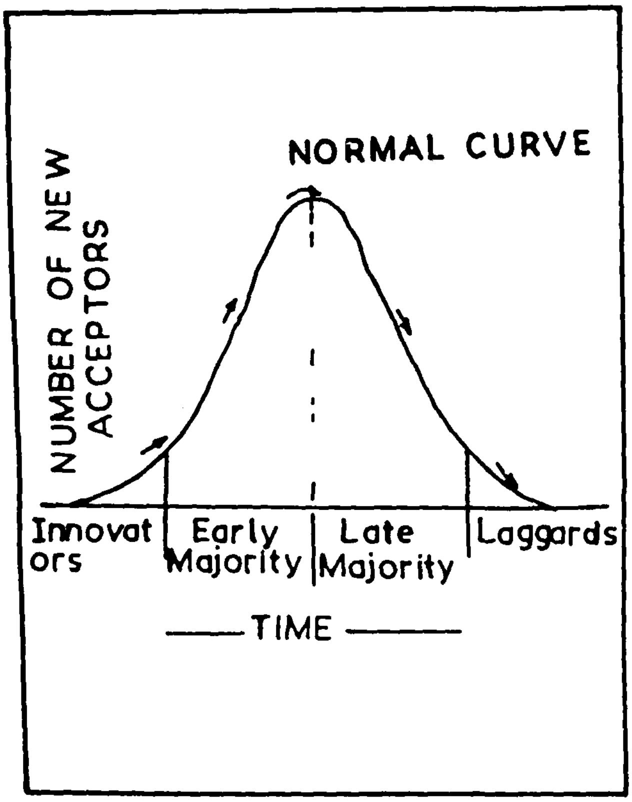
Fig. 1.2

C. **The Condensing Stage**: In this stage the relative increase in the numbers of accepting an item is equal in all locations, regardless of their distance from the original innovation centre.

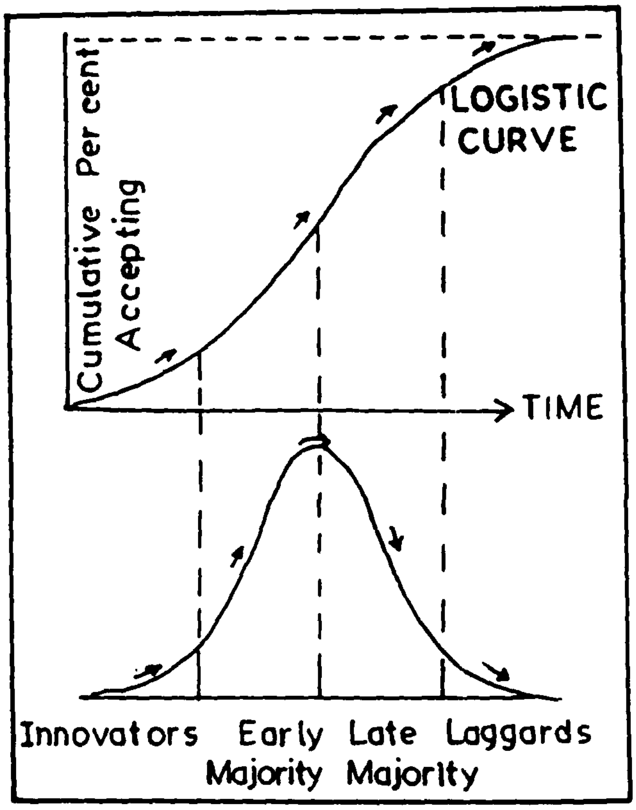
D. **The Saturation Stage**: The final (saturation) stage is marked by slowing and eventual cessation of the diffusion process, which produces a further flattening of the acceptance curve. In this final stage, the item being diffused is accepted throughout the region or country so that there is very little regional variation (Cliff and Hagget, 1981)[16].

The shape of diffusion is said to presumed wave like from when drawn through time and space. The transforming character of innovation waves is simply remarkable with distance from the time and point of origin. The slow weakening of waves counts on both space and time. The process of adoption of an innovation is not free from harshness. There are several kinds of adopters of innovations, e.g., early adopters, early majority, late majority and laggards. This concept originates from the fact that for any innovation there will be a few pioneers, a large number of early adopters and then the bulk of population leaving only a small number of laggards who will adopt much latter. This is because of different levels of resistance exercised by population while adopting an innovation. Hagerstrand (1968)[17] has observed that if population of adopters is accumulated and mapped through time the curve will be logistic or S-shaped Figure 1.3.

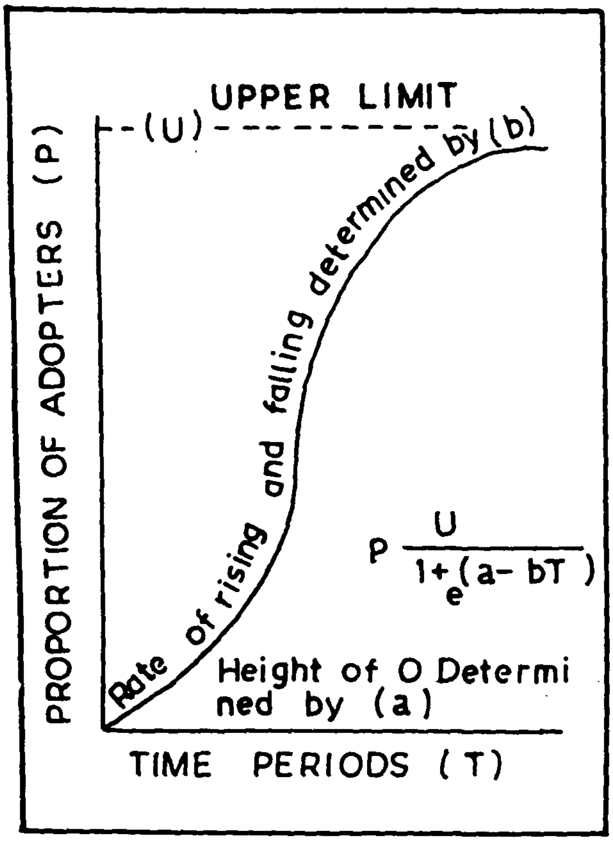
Curve shows the slow taking-off stage of varying length, an intermediate stage of more rapid development and a final stage of declining growth, which asymptotically seems to approach a ceiling.



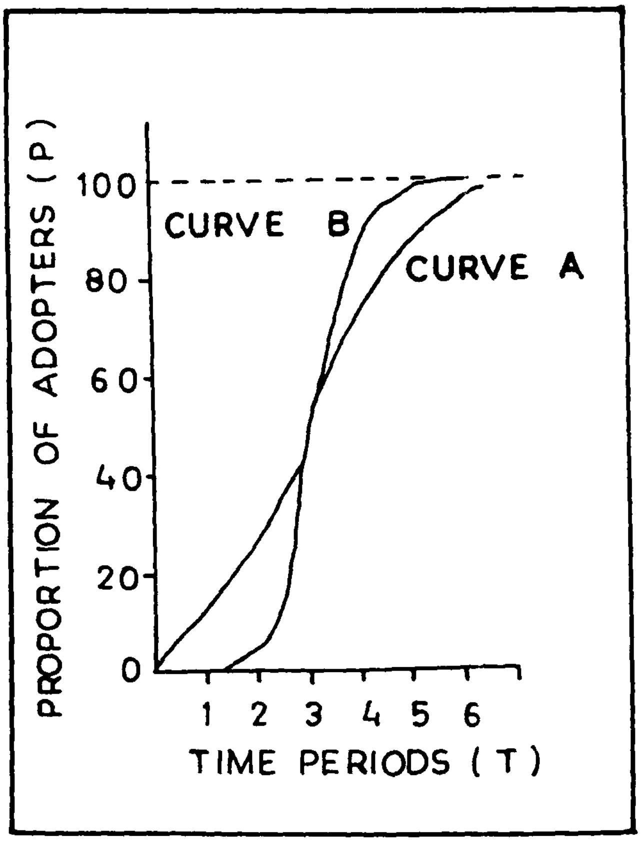
DISTRIBUTION OF INNOVATION ACCEPTORS



ACCUMULATING THE DISTRIBUTION OF INNOVATION ACCEPTORS



THE LOGISTIC CURVE OF INNOVATION ADOPTION



CURVES OF INNOVATION ADOPTION CONTROLED BY DIFFERENT PARAMETERS

Fig. 1.3

35 Work Review Done So Far

Thompson[18] (1926) analysed the relative productivity of British and Danish farming and expressed it in terms of gross output of crops and livestock. Ganguly[19] (1938) for computing productivity in agriculture of the Ganga valley presented a theoretical discussion. Kendall[20] (1939) expressed the productivity measurement as a mathematical problem and initiated a system of farm coefficients of productivity, ranking, money value and starch equivalent or energy. Hirsch[21] (1943) used 'Crop Yield Index' to measure productivity. Ryan Bryce[22] (1948) analysed the diffusion of hybrid seed cord as technological development in terms of time
36 sequence in cultural change. Hagerstrand[23] (1952) explained the idea of diffusion of innovation in agriculture by enlisting six components in this process (i) area, (ii) time, (iii) item, (iv) origin, (v) destination and (vi) path. Bennet[24] (1953) examined the speedy development of agricultural innovations by considering the socio-economic conditions of the farmers. Thirumalai[25] (1954) pointed out the ways to gain immediate and in long term with the use of modern techniques and implements further he discussed the problems in agricultural development in India. Lindstroms[26] (1958) emphasised the rapid diffusion of innovation like Japan and Netherland without neglecting the will of farmers. Stamp[27] (1958) applied calorific value of farm production in measuring the agricultural productivity. Ramsey[28] et al. (1959) examined the problems that arise during acceptance of new innovation and its diffusion. Shafi[29] (1960) used Kendall's "ranking coefficient" in calculating the agricultural efficiency in Uttar Pradesh. Bose[30] (1961) explained the characteristics of farmers who adopt the improved practices earlier. Commen[31] (1962) measured the productivity on the basis of yield per acre while working out the

trends of agricultural productivity in Kerala. Fliegel[32] (1962) examined the relationship between traditionalism and technical change among the farmers' families. Mechenzie[33] (1962) evaluated the agricultural production in Canada by using the coefficient of output relative to input. Dasgupta[33] (1963) explained three types of adopters of innovation, viz., innovators, early adopters and late adopters with certain variables. Bose[34] (1964) examined whether the adoption of innovation follows any definite pattern. Chatterji and Maitreya[35] (1964) expressed the levels of agricultural development and productivity during given point of time in West Bengal. Garg[36] (1964) explained the trends in agricultural development with respect to total cropped area, gross cropped area and food grain production in the different districts of Uttar Pradesh. Singh and Misra[37] (1964) suggested certain changes for increasing the area under cultivation including current fallow by more than eight percent. Bose and Saxena[38] (1965) examined the impact of socio-economic factors on diffusion of innovations. Khusro[39] (1965) correlated assessment of productivity with the output unit of a single input and output per unit of cost of all inputs in the agricultural production. Bose and Saxena[40] (1966) explained that the larger livestock, higher education and greater participation in community activities tended to promote adoption of innovations in agriculture. Desai and Misra[41] (1966) analysed the causes of growth in food production to make almost self sufficient in food grain and concluded that technological advancement and adoption of innovations are the main causes. Oammen[42] (1966) discussed the term technological change means all kinds of innovations and inventions, which are aimed at increasing the efficiency of agricultural productivity. Jain[43] (1966) emphasised that mechanisation is highly responsible for raising the agricultural productivity. Panse and Singh[44] (1966) analysed that the technological change is one of the critical factors in the development of Indian agriculture, which consists of adoption of farming techniques. Savale[45] (1966) expressed the diffusion of innovation as a process in the course of which those who have not adopted it earlier adopt an innovation. Frank[46] (1967) explained that there is no association between adoption and new farm practices and net farm practices. Misra[47] (1968) emphasised that there is an overwhelming need of innovation, diffusion and adoption of improved ideas and practices in almost all the fields of human activity for agricultural development. Kanwar[48] (1969) explained that for a minimum output from land it is necessary to bring more land under irrigation, fertilizers, high yielding varieties and better agronomic technology. Kumaraswamy[49] (1969) discussed the importance of cooperation in the development of agriculture providing loans and other important inputs.

39 Bardhan[50] (1970) concluded on intensive study of the effects of the green revolution on agricultural labourers. Chaudhari[51] (1970) examined that farmers, in order to produce more, need to spend more on improved inputs, which must be financed without saving, or borrowing. Nath[52] (1970) suggested that the development of cooperatives and expansion of infrastructure would help in the development of Indian agriculture. Jain[53] (1970) analysed that agriculture is now paying well on account of the availability of a wide array of HYV and hybrid seeds. Hayami and Ruttan[54] (1970) explained technological change as "any change in production coefficient resulting from purposeful resource. Using activity directed to the development to new knowledge embodied in design, materials or organisation. Shafi[55] (1972) used formula for both to determine the productivity of a particular crop with reference to yield per hectare and the area of that crop in the district in relation to the national level. Sachchidananda[56] (1972) examined several

objectives for the survey; (i) to identify the social correlates of adoption in improved agricultural practices, (ii) to categorise the adopters into first adopters, early adopters, later adopters and laggards, (iii) to identify the barriers to adoption and (iv) to discover the important elements of communication for the agricultural innovations. Parthasarthy and Prasad[56] (1974) explained that it is the larger farmers who make up the largest component of those adopting the new technology. Mohammad[57] (1974) emphasised that the non linear regression to forms of exponential are used and tested. They are Second Degree Curve and Logistic Curve. A straight line indicates a constant amount of increase or decrease, a Second Degree Curve involves increasing or decreasing amount of increase and decrease.

Bhati[58] (1975) concluded that those farmers who continue using green revolution technology usually operate farms, which are on an average larger than whose operators do not adopt the techniques. Hagerstrand[59] (1975) explained the concept of diffusion as an inimitable model of time-space relationship, which forms an important aspect in geography. Mohammad[60] (1976) pointed out that, for increasing production and bringing about a remarkable result immediately after the introduction of an innovation. Sharma[61] (1976) expressed that the development of agriculture should be assessed not only by productivity levels but also with reference to input such as improved varieties of seeds and irrigation. Bhalla[61] (1977) examined that the variation in the agricultural productivity is important mainly by the nature of various inputs of technology. Roy[62] (1979) emphasised that the irrigation development and improved water management are crucial to agricultural development of India. Arora and Sharma[63] (1981) suggested to increase area under pulses or other non-fertilizer using crops, where as HYV of wheat and paddy may be raised under irrigated conditions. Shafi[64]

(1981) pointed out that the irrigation is indeed the surest way in which agricultural production could be increased. Shafi[65] (1981) pointed out that agricultural development depends on a larger extent to the level of technology and the system of farming. Mohammad[66] (1981) emphasised that the use of modern technology for bringing about a change in agricultural output. Mohammad[67] (1981) examined that India can increase its agricultural production to a larger extent, if adequate and assured irrigation facilities are made available. Sharma[68] (1984) suggested that all agricultural productive activities require for their sustenance to some degree of credit. Singh[69] (1984) emphasised that the use of irrigation, HYV and fertilizers can not increase agricultural productivity unless the farmers are educated for the judicious use of the implements. Quizon[70] (1985) examined the role of fertilizer in the development of agriculture. Arshad[71] (1986) explained that the introduction of HYV along with new technology and fertilizers alone couldn't balance agricultural production. Goud[72] (1987) revealed that the extending proper financial assistance to the farmers so frees them from clutch of moneylenders and they help in rapid agricultural development. Vasant[73] (1987) emphasised that the supply and application of all other inputs needed for irrigated agriculture can produce sufficient food-grain for over increasing population of India. Ghosh[74] (1997) examined that there are different types and forms of diffusion. Some experiences regarding spread and adoption of ideas and practices seemed to be necessary in order to test the validity of the theories of diffusion.

Data Base

The study is based on the analysis of statistical data covering the period from 1970–71 to 1993-94 collected from both primary and secondary sources at districts and tehsils level. The primary data were collected through well prepared questionaires, taking into account of all the variables related to agricultural development and diffusion of innovations. The village level informati0on was collected from the selected respondents and Gram Pradhans, Sarpanchs and the Gram Vikas Adhikaris of the sample households and villages located in varied physical setting of different districts.

Sources of Secondary Data

33 In the present study the secondary data has been obtained from the published literature, government reports and district statistical bulletins, daily and weekly newspapers and unpublished records of the public administration and semi-government agencies. The sources of secondary data utilised in the present study are enlisted in the following succession:

34

(i) Survey of India Toposheets.
(ii) Census of India Statistics.
(iii) District Gazetteers of Saharanpur, Bulandshahr, Meerut. Muzaffarnagar and Ghaziabad.
(iv) State Administration Statistical Bulletin.
(v) Village and Town Directories of Saharanpur, Bulandshahr, Meerut, Muzaffarnagar and Ghaziabad.
(vi) District Census Handbooks of Saharanpur, Bulandshahr, Meerut, Muzaffarnagar and Ghaziabad.
(vii) Conference Proceedings.
(viii) Newspapers and other Periodicals.
(ix) Uttar Pradesh, Agricultural Statistical Bulletin.
(x) Departmental District Head Office Records.

Methodology

The qualitative and quantitative techniques have been used for the analysis of the present study are as under:

(i) Descriptive approach has been adopted to put down the account of physico-cultural account of study area.

(ii) Interpolation method has been followed to represent relief of the region by taking spot heights as the base.

(iii) For determining the development of agriculture by techno-institutional factors, per thousand hectare of land has been chosen as unit of mechanization, by knowing the number of electric pumps, tractors, threshers, fertilizer drillers, seed drillers, diesel pumps, ploughs per thousand hectare. Besides, size of holding and consumption of fertilizer kg per hectare.

(iv) Second degree and logistic curves have been used to analyse the trend of diffusion of innovations. Logistic curves are Pearl-Reed curve which is merely a modified by exponential curve i.e.,

$$Y_c = \frac{K}{1+10^{a+bx}}$$

Where K, a and b are constant and x is time variable

Second degree curve is represented by $Yc = a + b + cx^2$

(v) Coefficient of correlation has been used to examine the efficiency of the second degree curve and logistic curve in between observed and calculated values.

41 (vi) Weaver's minimum deviation method has been used to find out different crop combination regions. Formula is given as $d = \frac{d^2}{n}$ by calculating deviation from the real percentages of crops for all possible combinations in the compound aerial units against theoretical standard.

(vii) Kendall's Ranking method has been used to analyse the various crops under different scale of preference over a period of time.

(viii) For the determination of productivity the value is represented in terms of Rs. per hectare by per unit of area converting the volume of products of all the crops into Rs. at current price.

(ix) To work out the trend of agricultural development, trend line has been fitted the regression line of the form Yc = a + bx. Regression line make it possible to predict the exact change in the production level in various time points. Further, coefficient of correlation is worked out between area and production; and between area and yield for selected crops and it is tested for significance by 't test'.

42 (x) Techniques of composite Z score has been employed to determine the levels of diffusion of innovations and the correlation between agricultural productivity and diffusion of innovations. Standard score (Z score), is represented by.

$$Z = \frac{x - \bar{x}}{SD}$$

Z = Standard score

x = Original value of the observation.

$\bar{x}$ = Mean for all the values of x.

SD = Standard Deviation of x.

43 **Hypothesis**

(1) The farmers of large size of holdings tend to adopt improved agricultural practices more than the farmers of other size of holdings.

(2) The rate of adoption among owner farmers is high as compared to owner share-cropper or share-cropper.

(3) The farmers having adequate and assured irrigation facilities are more adoptive of agricultural innovations as compared to others.

Repetiti

(2) The rate of adoption among owner farmers is high as compared to owner share-cropper or share-cropper.

(3) The farmers having adequate and assured irrigation facilities are more adoptive of agricultural innovations as compared to others.

44 (4) Adequate and timely availability of power tends to promote speedy adoption of agricultural innovations among farmers.

(5) Availability of adequate and timely credit facilities promotes quick adoption of agricultural innovations.

(6) Availability of incentives in the form of subsidies tends to promote speedy adoption of improved agricultural practices.

(7) Timely and adequate availability of inputs promotes adoption of agricultural innovations.

(8) The rate of adoption of an innovation is positively related to its ultimate returns.

(9) Availability of incentives in the form of assured fair prices for agricultural produce tends to promote speedy adoption of agricultural innovations.

(10) The high adoption diffusion of innovations is directly proportional to high productivity.

45

Objective

The objective of the present study is:

(1) To assess the advancement in agriculture and to analyse the contribution of different techno-institutional factors i.e., number of electric pumps per thousand hectares, number of threshers, number of seed drillers, number of diesel pumps, number of ploughs, number of tractors per thousand hectare, different sources of irrigation and size of land holdings.

(2) To identify the inter district variations in agricultural development and trend of diffusion of innovations.

(3) To establish relationship between area and yield and area and production.

(4) To identify the factors causing variations in yield in different districts and tehsils of the region, including specific technological inputs irrigation, fertilizers, HYV and use of implements.

(5) To trace out the association of various crops i.e., crop combination regions and intern tehsil variations in crop combination.

(6) To represent the ranks of various crops.

(7) To identify the factors of diffusion of agricultural innovations i.e., size of holding, tenure status, income and economic status, availability of irrigation, commercial orientation, caste status, social participation, urban and outside contact, extension contact, socio-economic status and mass-media.

(8) To identify different productivity region based on per hectare productivity in terms of Rs. per hectare.

(9) To establish relationship between irrigation facilities, consumption of fertilizers, use of implements and level of diffusion of agricultural innovations.

(10) To establish correlation between agricultural productivity and diffusion of innovations.

Plan of the work

The present study on "Diffusion of Agricultural Innovations in Upper Ganga-Yamuna Doab" has been organised into seven chapters, which are as follows:

Chapter I deals with the introduction comprises of conceptual framework of diffusion of agricultural innovations, a brief outlook of work review done so far, sources of data, consisting of primary and secondary, principles of methodology including qualitative and quantitative both, hypothesis, objectives of the study and plan of the work.

Chapter II examines the various physico-cultural and demographic factors of the study area to understand the casual relationship of all the factors with the diffusion of innovations as well as the productivity of the selected crops.

Chapter III presents the discussion of agricultural development comprises of (i) Technological and institutional advancement in agriculture with reference to time and space, patterns of modern agricultural technology consisting of tractors, electric pump sets, diesel pump sets, iron plough, wooden plough and other improved tools. Besides, these two major advancing techno-institutional factors agricultural labourers, agricultural credit, pattern of land ownership, pattern of irrigation and consumption of fertilizers has also been taken into consideration; (ii) The sub chapter of development of agriculture includes the trend of agricultural development encompassing with the study of area, production and yield through time and space, changing landuse pattern, cropping pattern, intensity of cropping, production variability, yield variability; (iii) Moreover, it has also been focussed towards the study of agricultural productivity comprises of regionalisation of agricultural productivity, crop combination and ranking of crops.

Chapter IV studies the trend of diffusion of agricultural innovations including the factors of diffusion of agricultural innovations and various physio-cultural and socio-economic variables. It further examines the trend of diffusion of agricultural innovations; consumption of fertilizers and use of irrigation of the different districts of Upper Ganga-Yamuna Doab and the region as a whole.

Chapter V deals with the level of diffusion of Innovations comprises of irrigation, fertilizer and implements. Besides the composite scores of different sources of irrigation, consumption of fertilizer and various forms of tools and implements of diffusion of agricultural innovations have been taken into account. Moreover, the correlation between agricultural productivity and diffusion of agricultural innovations has been analysed.

Chapter VI presents a comprehensive study of the first hand information regarding the impact of techno-institutional and socio-economic factors on diffusion of agricultural innovations. The present chapter also examines the various hypotheses of the adoption of agricultural innovations vs. various factors such as size of land holding, tenurial status, irrigation, electric and diesel power, credit, subsidy, inputs, yield, fair prices, level of exposure to mass media, level of education and social position.

Chapter VII the last chapter presents epitomize work of the study area and it has incorporated many more suggestions regarding the diffusion of agricultural innovations and also generated various interests of further research on diffusion of agricultural innovations at micro-level.

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CHAPTER II

GENERAL PHYSICAL AND DEMOGRAPHIC SETTING

GENERAL, PHYSICAL AND DEMOGRAPHIC SETTING OF UPPER GANGA–YAMUNA DOAB

The Upper Ganga-Yamuna Doab is agriculturally developed region of Uttar Pradesh. It lies in the northwestern part of the state, between the two master streams the Ganga and the Yamuna (Figure 2.1). It covers an area of about 20624sq. km. It is a monotonous and fairly productive plain. The northern boundary of this region is formed by the Siwaliks, the watershed of which separates this area from the district of Dehradun. The Ganga and Yamuna form the eastern and western boundaries respectively. The Ganga, which flows along the eastern border from north to south, separates this region from the districts of Garhwal, Bijnore, Moradabad and Badaun. The river Yamuna separates this region from the districts of Ambala, Karnal, Panipat, Sonipat and Gurgoan of Haryana and Union Territory of Delhi. The southern boundary is formed by the political boundary of Aligarh district (Figure 2.2)

The Upper Ganga-Yamuna Doab consists of the districts namely, Saharanpur, Muzaffarnagar, Meerut, Ghaziabad and Bulandshahr (Figure 2.2 and Table 2.1). The region lies in between $28^{0}4'$ to $30^{0}24'$ north latitude and $77^{0}2'$ to $78^{0}29'$ east longitudes. According to 1991 census, it accounts of 14,243,132 population with a density of 690 persons per square km.

Cultivation of crops has been the main occupation of the people in the region. The economic classification of the population shows that about 24.32 percent of total population are the main workers, 5.01percent are marginal workers and about 70.47 percent are non-workers. Among the workers, 39.61 percent are cultivators, 21.29 percent are agricultural labourers, 5.41 percent are engaged

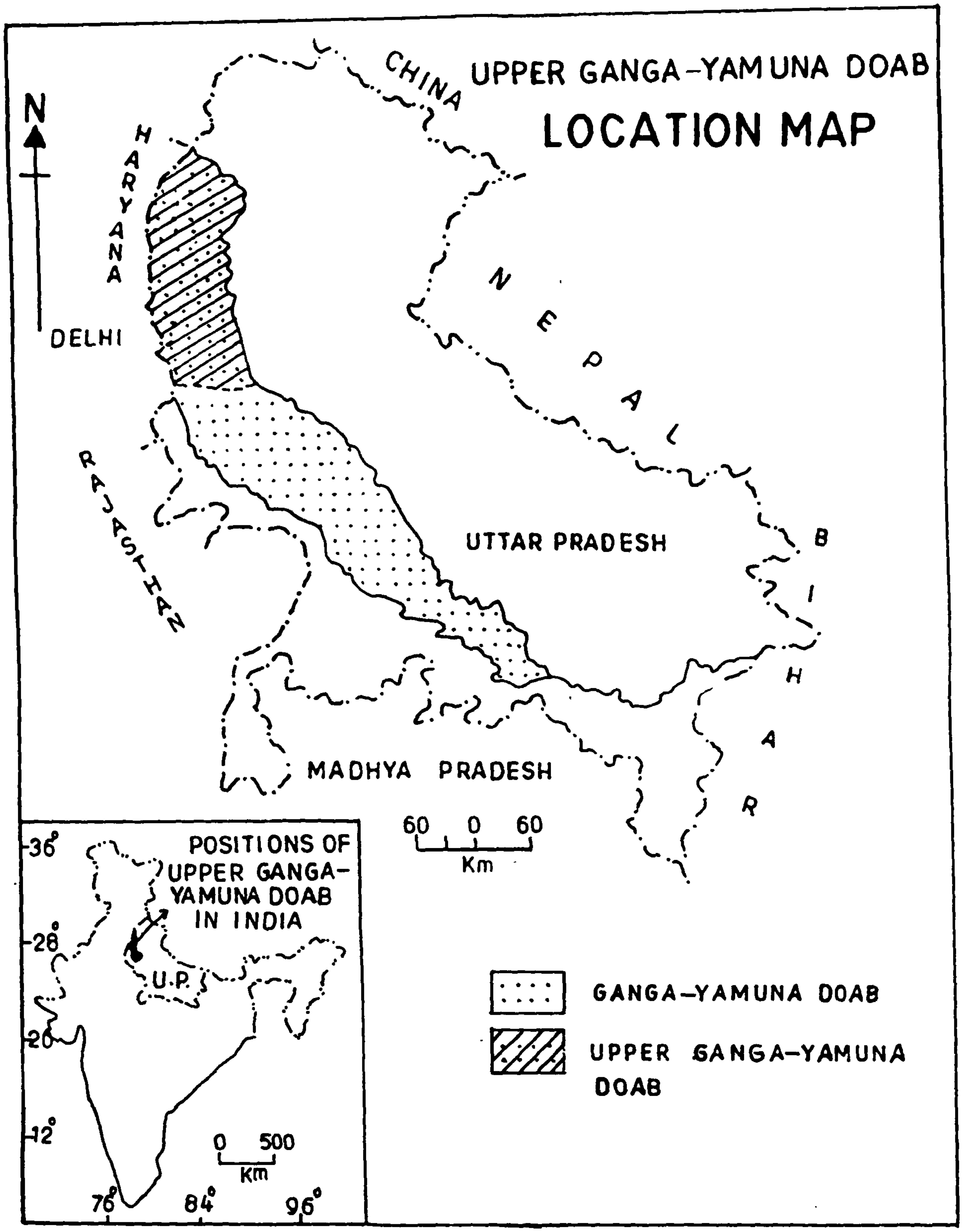
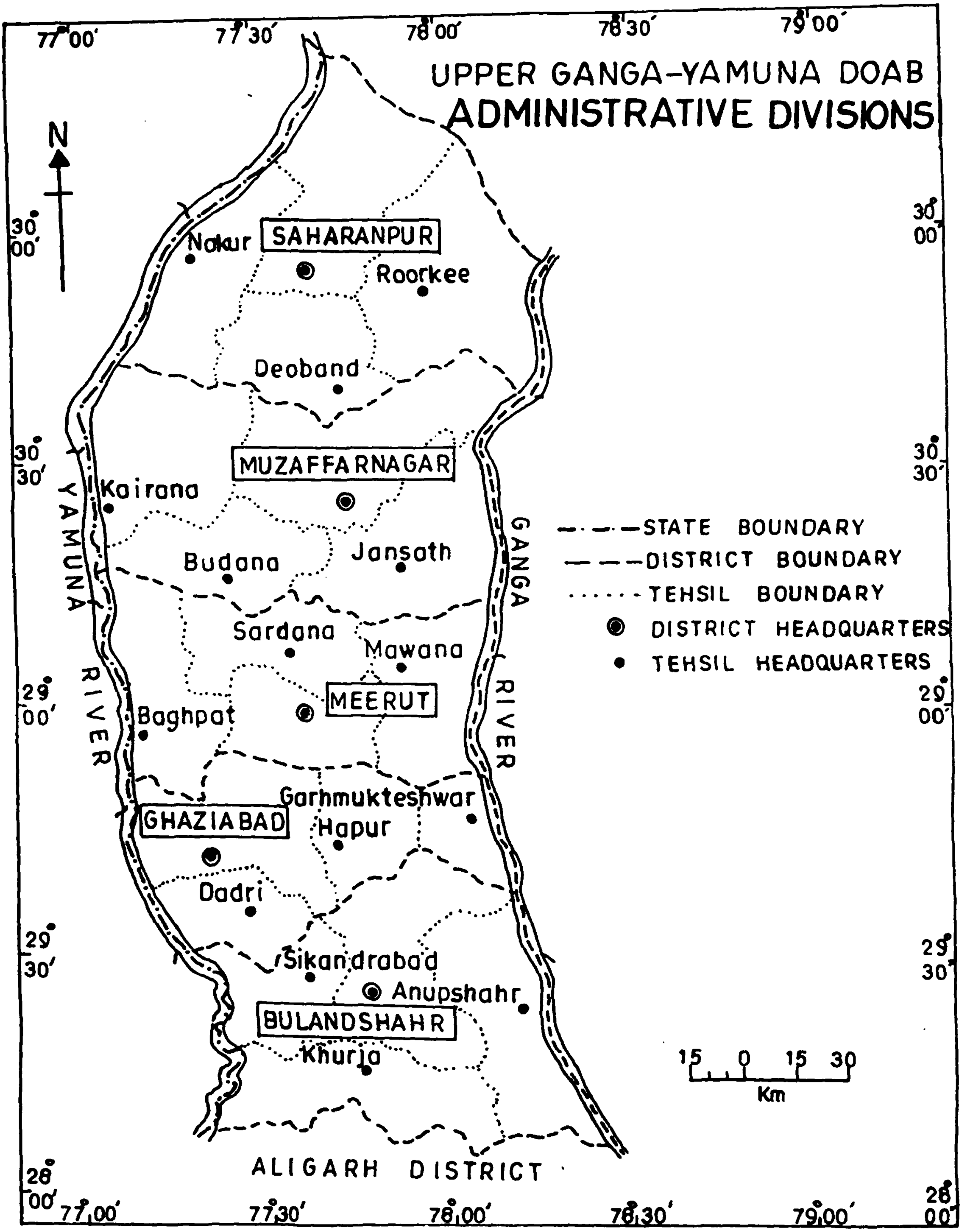

UPPER GANGA-YAMUNA DOAB
LOCATION MAP
N
CHINA
HARYANA
DELHI
NEPAL
RAJASTHAN
UTTAR PRADESH
BIHAR
MADHYA PRADESH
60 0 60
Km
POSITIONS OF UPPER GANGA-YAMUNA DOAB IN INDIA
36°
28°
20°
12°
U.P.
0 500
Km
76°
84°
96°
GANGA-YAMUNA DOAB
UPPER GANGA-YAMUNA DOAB

Fig. 2.1



UPPER GANGA-YAMUNA DOAB
ADMINISTRATIVE DIVISIONS
N
77°00′
77°30′
78°00′
78°30′
79°00′
30° 00′
30° 30′
29° 00′
29° 30′
28° 00′
SAHARANPUR
Nakur
Roorkee
Deoband
MUZAFFARNAGAR
Kairana
Budana
Jansath
Sardana
Mawana
MEERUT
Baghpat
Garhmukteshwar
GHAZIABAD
Hapur
Dadri
Sikandrabad
Anupshahr
BULANDSHAHR
Khurja
ALIGARH DISTRICT
YAMUNA RIVER
GANGA RIVER
STATE BOUNDARY
DISTRICT BOUNDARY
TEHSIL BOUNDARY
DISTRICT HEADQUARTERS
TEHSIL HEADQUARTERS
15 0 15 30
Km

Fig. 2.2

Table 2.1

Administrative Division of Upper Ganga-Yamuna Doab (1991)

District / Region	Saharanpur	Muzaffarnagar	Meerut	Ghaziabad	Bulandshahr	Upper Ganga-Yamuna Doab
1. Area (Sq. Km)	5595	4176	3911	2590	4352	20624
2. No. of Tehsils	4	4	4	4	4	20
3. No. of Blocks	16	14	18	10	17	75
4. No. of Towns	16	18	23	13	22	92
5. No. of Villages	1700	927	920	704	1363	5616

Source: Census Report, Directorate of Census Operation, Uttar Pradesh (1991)

Table 2.2

Economic Classification of Population in the Upper Ganga-Yamuna Doab (1991)

District / Region	Saharanpur	Muzaffarnagar	Meerut	Ghaziabad	Bulandshahr	Upper Ganga-Yamuna Doab
1. Total Population.	2301886	2928927	3430398	2733494	2826427	14243132
2. Percentage of rural population to total population	72.91	78.28	60.77	63.86	80.76	73.42
3. Percentage of urban population to total population	27.08	21.71	39.22	34.13	19.33	26.5
4. Density of population (per. sq. km.)	411	701	877	1064	649	690
5. Percentage of workers to total population	38.16	28.48	27.68	27.46	23.88	29.53
6. Percentage of cultivators to total workers	32.88	36.70	32.71	25.69	46.23	39.61
7. Percentage of agricultural labourers to total workers	28.69	28.09	18.92	12.34	18.23	21.29

Source: Census Report, Directorate of Census Operation, Uttar Pradesh (1991) in household industries and the remaining 26.27 percent are engaged in other occupations.

Area-wise, Saharanpur (5595 sq. km.) is the largest district followed by Bulandshahr (4352 sq. km.), Muzaffarnagar (4176 sq. km.), Meerut (3911 sq. km.) and Ghaziabad (2590 sq. km.). The most densely populated district is Meerut (877 persons per sq. km.), followed by Muzaffarnagar (701 persons per sq. km.), Bulandshahr (649 persons per sq. km.) and Saharanpur (411 persons per sq. km.). Bulandshahr district (46.23 percent) has the highest percentage of cultivators followed by Muzaffarnagar (36.70 percent), Saharanpur (32.88 percent) Meerut (32.71 percent) and Ghaziabad (25.69 percent) Table 2.2.

Agriculture productivity is the function of number of factors including physical (relief, altitude, climate, soil), socio-economic (size of holding, tenancy system, occupational structure of population, literacy level), and technical organizations, crop rotation, irrigation, use of chemical fertilizer and mechanisation. All these factors are highly variables and dynamic both in space and time leading to spatio-temporal variations in agricultural productivity. Therefore, in order to do rational and scientific planning for the agricultural development of an area at any level, it is imperative to assess the agriculture productivity of the region and also impact of diffusion of innovation in the study area. With this view an attempt has been made to review the various factors determining the diffusion of innovation.

The diffusion of agriculture innovation is depending upon the quality of demographic attribute. The physical attributes of an area become resource only when the people are able to use them. The relation between population and land use of reciprocal. Hence, the pressure of population, male, female ratio, literacy level, agriculture main workers, agriculture labourers, density of population, scheduled cast and scheduled tribes population have been analysed in the region at the district level.

Structure and Relief

Upper Ganga-Yamuna Doab structurally forms the part of Indo-Gangetic plain, which lies in between the northern peninsular India and the recently built Himalayan chain. The plain is 402 km. wide in its broadest part and about 2414 km. long.

The origin of the plain has been a matter of controversy. Eduard Suess, the Australian geologist holds that it is a foredeel formed in front of the resistant mass of the peninsula, when the Tethys sediments thrust southward and compressed against them[1]. The peninsula is regarded as a rigid stable mass and the central Asia as a moving segment of the crust. The eroded material gradually filled in the foredeep from the Himalayas and the old shield of the south, and thus the plain came into existence[2].

According to S.G. Burrard, the plain constitutes a rift valley and is bounded by parallel faults on its two side with the maximum down trough of 32 km.[3] Burrard's theory which is based on the geodetic observations and deductions is neither supported by geological facts nor in conformity with the geo-physical observations[4]. According to the general belief this sunken belt which is of Pro-Eocene time formed, part of the peninsular tableland south of the Tethys and developed concommitantly with the elevation of Himalayas[5].

On the basis of characteristics Gondwana rocks found on the northern rims of the alluvial belts, Wadia and Auden maintain that the peninsular rocks (viz., Archean gneiss) are continuos inside the plain. The continued loading of this belt by sedimentation, since the first uplift of the mountains may have accelerated by sinking of the

Archean floor, but as the process of sedimentation kept pace with that of depression, there arose the great plain of India[6].

The depression of Indo-Gangetic plain perhaps began to develop in the Upper-Eocene and attained its greatest development during the third Himalayan upheaval in the Middle-Miocene. Since then it has been filled by sediments, and formed a level plain with a very gentle seaward slope[7].

Nature of Deposits

The nature of deposits is consist of silts and clays with occasional gravels. The rocks in general are every where of alluviatile and subarial formations, massive beds of clay, either sandy or calcareous, corresponding to the silt, mud and sands of the modern rivers[8].

A characteristic feature of the plain particularly in the older parts i.e., bhangar land is consist of calcareous matter in the form of irregular concentration[9]. In the southern part of Upper Ganga-Yamuna Doab i.e., in Meerut and Bulandshahr districts such formations are totally absent[10].

The major geological formations of Upper Ganga-Yamuna Doab can be classified as follows:

i).	Recent	recent alluvium, sandy soils (khadar land).
ii).	Pliestocene	older alluvium (bhangar land).
iii).	Postpoliocene	Siwalik deposits.

In regards to the geological depositions of the plain no marked stages of deposition occur. According to Wadia, the alluvium deposit can be divided as follows:

i). the newer alluvium known as khadar; and

ii). the older alluvium known as bhangar.

Figure 2.3 shows the distribution of khadar and bhangar in Upper Ganga-Yamuna Doab. Bhangar corresponds to the age of Pleistocene and occupies the higher ground. The flooded rivers usually do not reach the bhangar lands except in years of exceptionally high floods. The newer alluvium or khadar lands are younger in age as compared to the bhangar. The main khadar lands are strips of lands along the banks of the Ganga–Yamuna and in small width along the valley of other streams of Upper Ganga-Yamuna Doab. The khadar land being a lowlying area is occasionally inundated by floods. The absence of gravels, the presence of fine sediments and the light colour are the remarkable features of the khadar soil[11].

There is hardly any unanimity as regard to the depth of the alluvium. The borehole to the west of the district of Saharanpur, at Ambala, is only 1612 feet and it has not touched the rock bottom[12].

The deepest borehole, i.e., at Lucknow in Uttar Pradesh, is only 1336 feet and this also did not touch the rock bottom[13] S.G. Burrard, who considered that the Gangetic alluivum occupied a narrow rift at the foot of Himalaya, the maximum depth of which was 32 km.14, interpreted the earlier Geodetic Survey Work of India. The Geologists believe that the maximum depth of the alluvium is near the foot of the Himalayas and becomes shallower towards the peninsula in the west of Delhi and Rajmahal hills[15].

Relief Features

The Upper Ganga-Yamuna Doab with the exception of its northern parts is a uniform level plain. The river valleys and the sandy undulations constitute the only irregular features of the Upper Ganga-Yamuna Doab. Siwalik Hills forms the northern boundry of the area, the watersheed of Siwaliks separates the district of Saharanpur from the district of Dehradun. In the sub-

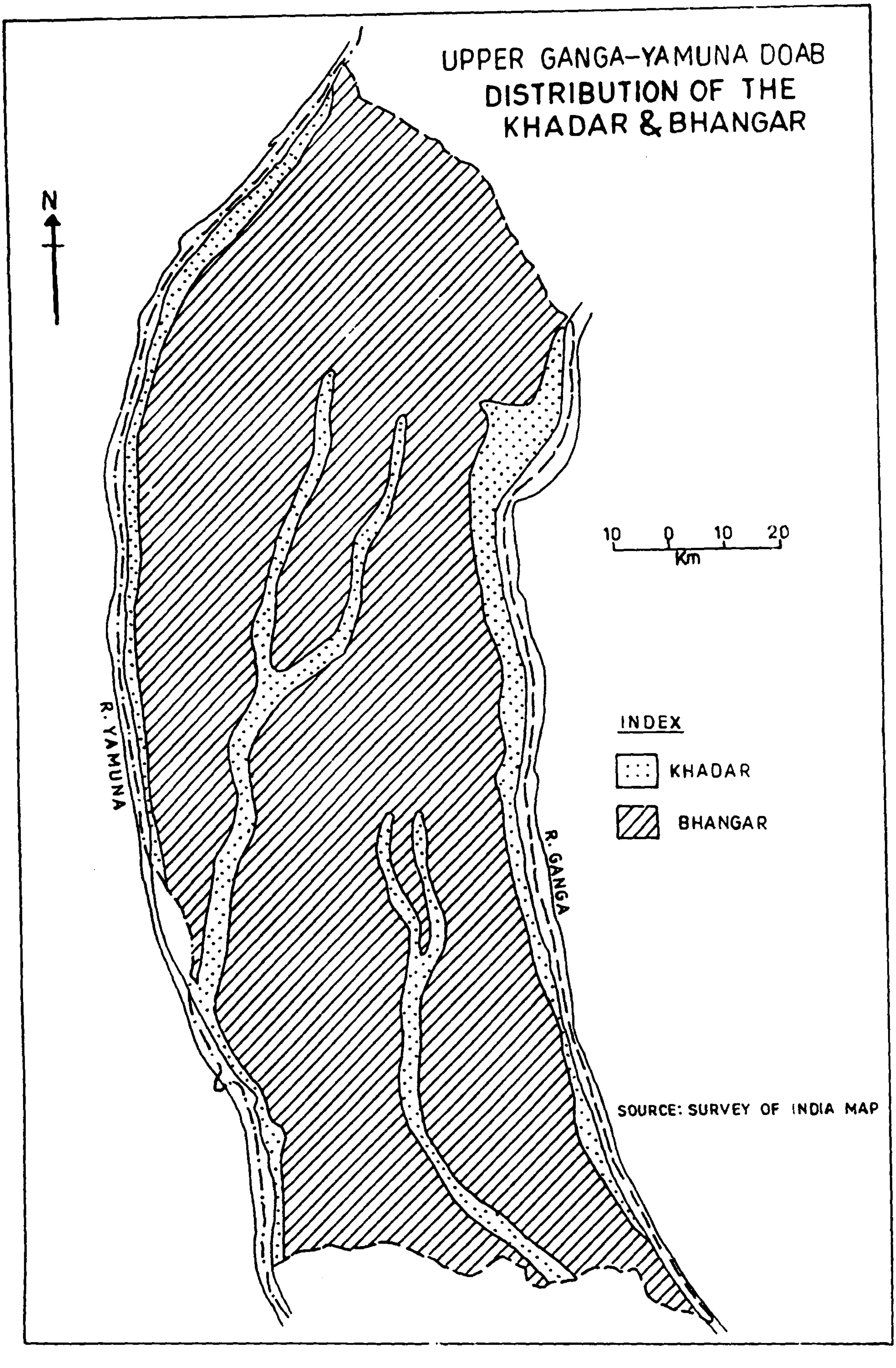

UPPER GANGA-YAMUNA DOAB
DISTRIBUTION OF THE
KHADAR & BHANGAR
N
10 0 10 20
Km
INDEX
KHADAR
BHANGAR
R. YAMUNA
R. GANGA
SOURCE: SURVEY OF INDIA MAP

Fig. 2.3

montane tract a variety of hill features can be seen. These features are gradually being sharpened under the influence of the various agents of erosion. The fertile river valleys are the dividing lines of the plains and the elevated topography of the north. The contour line of 1,000 feet above sea level can be taken as the northern boundary of the fertile cultivated area of Upper Ganga-Yamuna Doab. The general gradient of the area is from north to south. It will be seen from Figure 2.4 that the contour of 650 feet which crosses the district of Bulandshahr from west to east, passes almost along the southern part of the area under review.

Drainage

The drainage of Upper Ganga-Yamuna Doab with the exception of the lowlying parts is well developed. The courses of rivers and streams follow the general gradient of the plain, i.e., from north to south and south east.

The Figure 2.5 shows that the Ganga and the Yamuna are the two principal rivers of the Upper Ganga-Yamuna Doab. The remaining streams are minor and seasonal in nature. The discharge of the seasonal streams varies from nothing in the hot season to thousand of cubic feet per second during the rain, their beds may remains dry for months and then may be flooded for a few days in a year. To understand the nature of the principal rivers and to make a comprehensive study of the drainage of Upper Ganga-Yamuna Doab, the streams can be put into two classes:

i). The Ganga and its tributaries and

ii). The Yamuna and its affluents.

The Ganga

There has been a controversy about the source of the Ganga. There are numerous glaciers at the source of the river. From these

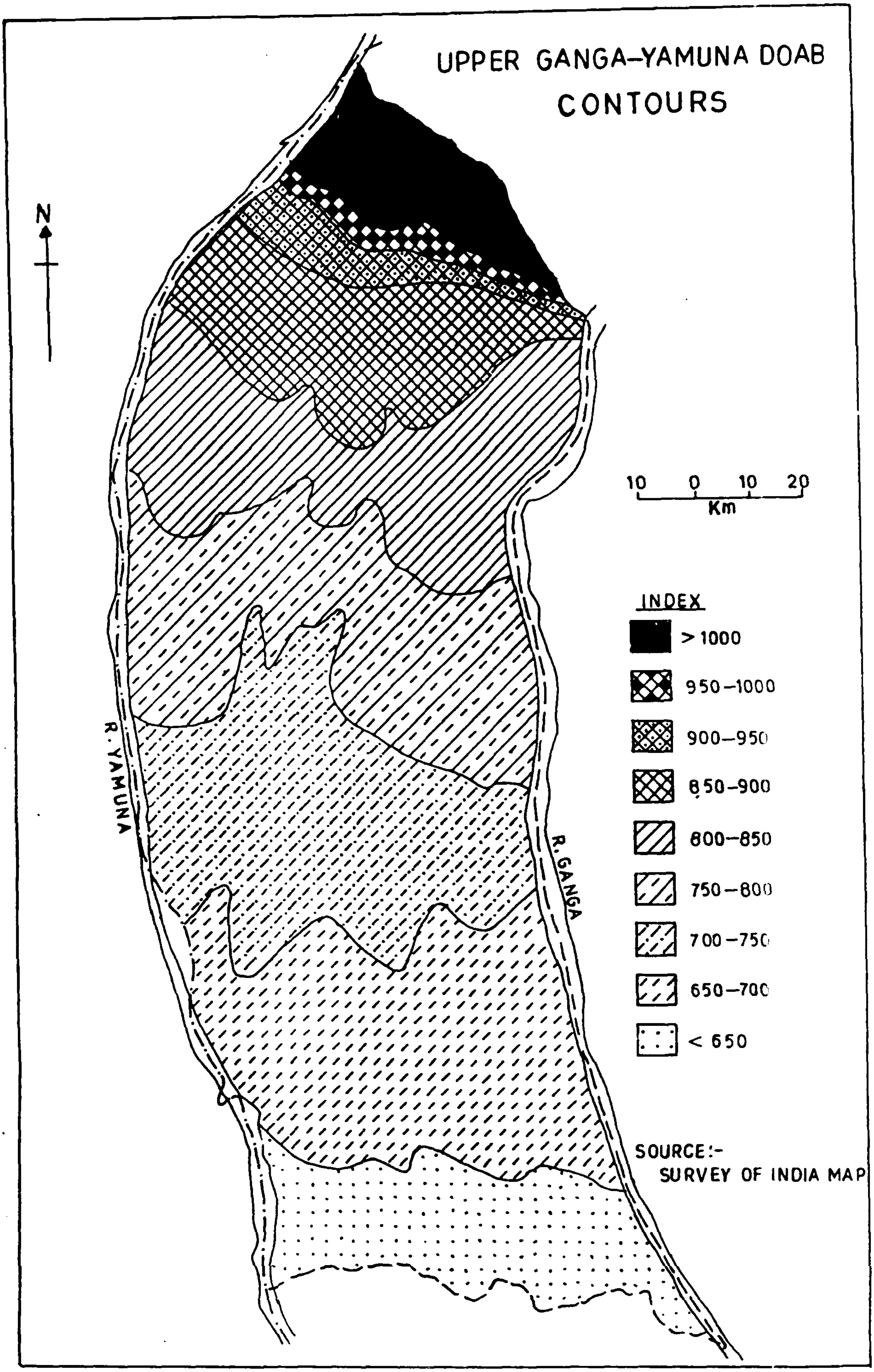

UPPER GANGA–YAMUNA DOAB
CONTOURS
N
10 0 10 20
Km
INDEX
> 1000
950–1000
900–950
850–900
800–850
750–800
700–750
650–700
< 650
R. YAMUNA
R. GANGA
SOURCE:-
SURVEY OF INDIA MAP

Fig. 2.4

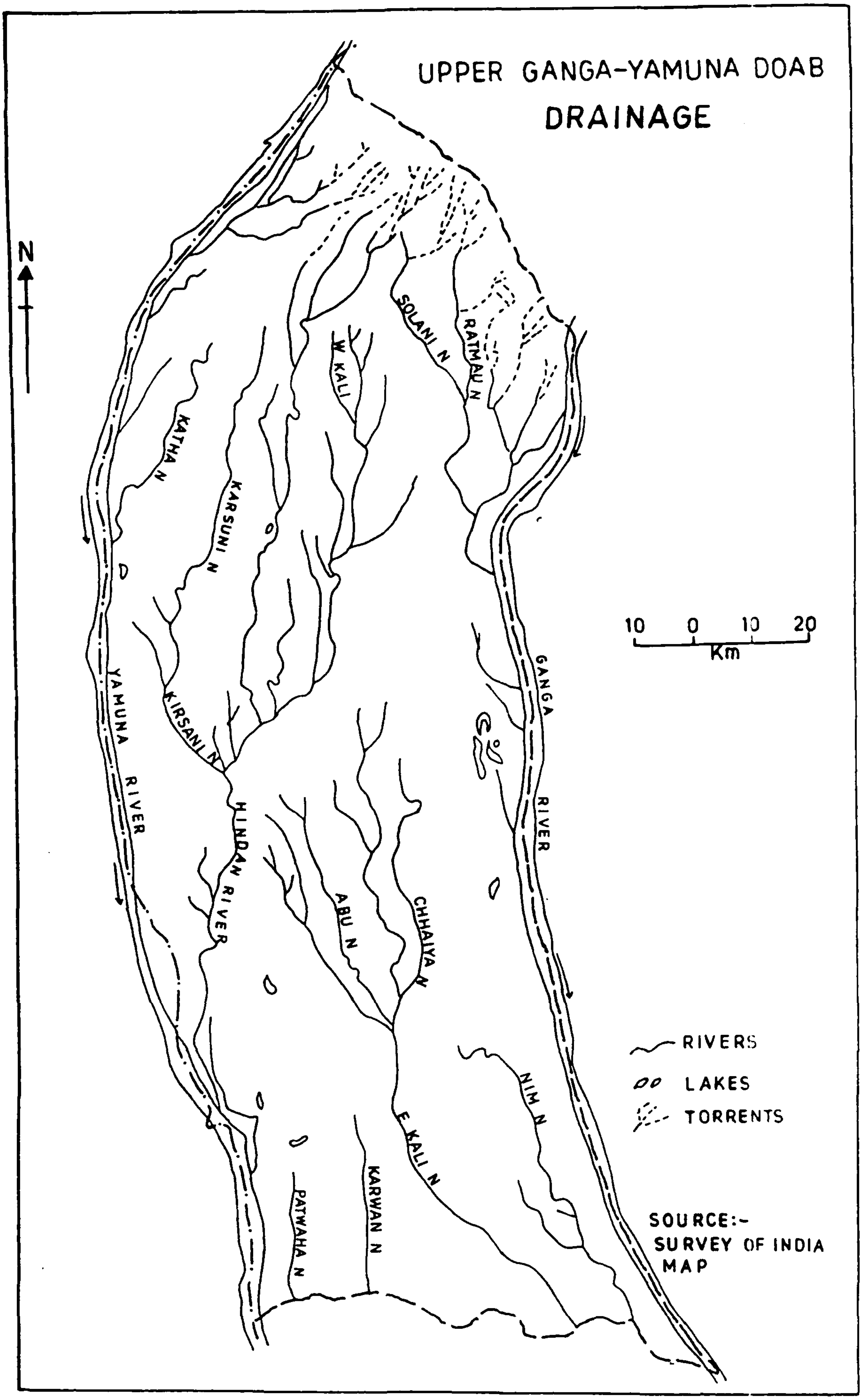

UPPER GANGA-YAMUNA DOAB
DRAINAGE
N
SOLANI N
RATMAU N
W KALI
KATHA N
KARSUNI N
KIRSANI N
YAMUNA RIVER
HINDAN RIVER
ABU N
CHHAIYA N
GANGA RIVER
10 0 10 20
Km
RIVERS
LAKES
TORRENTS
NIM N
E KALI N
KARWAN N
PATWAHA N
SOURCE:-
SURVEY OF INDIA MAP

Fig. 2.5

glaciers of Ganga river rises from the confluence of branches, known as Alaknanda and Bhagirati[16].

The Ganga touches the plain of Upper Ganga-Yamuna Doab at Hardwar, after traversing about 290 km. in the Upper Himalayas. At Hardwar it debouches in the plain through, as well marked gorge in the Siwaliks. The main stream of the river at Hardwar is known *Nildhara*[17].

The Upper Ganga canal has been taken out from Hardwar which accounts 10500 cusses of water is used to generate electricity and for irrigation purposes. The bed of the Ganga in the south of the Hardwar town is composed of boulders and calcareous rocks.

The Ganga leaves Saharanpur district at the village of Balawali and passing southward in the form of meanders. Before the coming up Narora barrage along river Ganga in the district of Bulandshahr the Ganga was navigable upto Hardwar.

The volume of water in the river increases by the middle and onwards due to melting of snow and heavy rain during monsoon in the month of July and August. The volume at Raiwala, about 10 km. above Hardwar town, frequently falls to less than six thousand cubic feet per second between January and March and sometimes even a longer figure is recorded, the smallest volume ever observed at this point being 4427 cusses in March, 1882. On the other hand the normal high flood discharge is calculated at 482000 cubic feet and this sometimes is largely exceeded. The maximum rising to 610660 cubic feet in 1880 and to no less than 700843 cubic feet when an abnormal flood was caused by the bursting of Gohna lake in the hill of Garhwal[18]. From time to time the Ganga has changed its course. About 1852 AD the Ganga changed its course distinctly towards the East. Upto 1885 AD Solani-*nadi* a small stream flowed into the Ganga in the district of Saharanpur, but now it meanders through the khadar of Muzaffarnagar district and meets the Ganga in the east of Bhukarheri village at a for southerly point than its previous position. This change has occurred owing to the east ward shift in the course of the Ganga[19]. The old bed of the Ganga now known as the Banganga (or 'Boorhi Ganga' which means old Ganga) leaves the main Ganga stream 6.5 km. south of the Kankhal town and joins the Ganga at the village of Bhukarheri in the district of Muzaffarnagar. The course of the Banganga a back water of the Ganga probably represents the abandoned course of the river. The great changes in the course of the river probably took place in about 1400 AD. It is believed that prior to 1400 AD the whole of the Gordhanpur and part of Manglaur *parganas*[20], now lies in the districts of Muzaffarnagar and Saharanpur respectively, were parts of the district of Bijnor[21] (Figure 2.5).

The tributaries of the Ganga in Upper Ganga-Yamuna Doab are hill torrents. These streams rise from the Siwaliks and crossing the khadar in the district of Saharanpur join the Ganga in the district of Muzaffarnagar. The stream of solani is the main tributary of the Ganga. Solani rises from the neighbouring part of Mohan-pass.

In the rainy season at the time of floods the Solani discharges 84000 cubic feet of water[22]. Ratmau is another important stream, which drains the submontane forests. Never the village of Sahalpur, the Ratmau stream assumes a southeasterly course and continues till it joins the Solani *nadi*.

The Yamuna

The Yamuna, rising from the snowy peaks of the Himalayas enters the plain at Khara, 198 km. south of its source, in the extreme north west corner of the district of Saharanpur. The deep channel of the river separates the plain of Upper Ganga-Yamuna Doab to that of the Punjab and Delhi.

The valley of the river in the mountainous region is bounded by high peaks and forms a succession of rapids. In the plain Yamuna flows into several channels and its course becomes broad In the middle part of the district of Muzaffarnagar it makes loops and sharp bends passing along the western border of Meerut and Bulandshahr district, it enters the district of Aligarh near the village of Jhuppa (Figure 2.5).

The velocity of the stream is slow and hardly exceeds 10 km per hour during the wet monsoon months[23]. The width of the stream in the rainy months extends upto 4 km. while in the dry months it is normally reduced to less than one furlong.

The Yamuna receives a number of major and minor streams on its left bank in the plain of Upper Ganga-Yamuna Doab. The important streams coming down from the southern phase of the Siwaliks are Badshahibagh-*Rao*, Raipur-*Rao*, Puhjna *nadi* and Markara-*Rao*. The *Budhi*-Yamuna leaves the Yamuna river, about 5 km. south of Faizabad town, flowing southward parallel to the main stream, it joins the Yamuna near the village of Pipli in the district of Saharanpur. Another tributary of the Yamuna in Saindhi *nadi*. It rises and flows to the southwestern part of the district of Saharanpur and attains a regular course in the west of the Gangoh town. It discharges its water in the Yamuna near the village of Dhakwala in Muzaffarnagar district. The Bhuria *nadi*, a minor seasonal tributary of the Yamuna, rises from the northwestern part of the district of about 5 km. and discharges its water into the Yamuna to the west of Dankaur town (Figure 2.5).

The Hindan

The Hindan can be described as the main drainage system of the area. It rises from the Siwaliks in the northern part of the district of Saharanpur. The channel of the stream is defined near the town of Muzaffarabad. Later, it is joined by many seasonal streams on its right and left bank. On the right bank it is joined by the streams of Nagadeo and Dhamola. The stream of Nagadeo is an important right bank affluent, which rises from Siwaliks and joins the Hindan at the village of Gaogreki, about 5 km. in the east of Saharanpur city. This stream receives the water of Kothari-*Rao* and flows with high velocity. The stream of Dhamola rises from the Siwaliks and flowing to the eastern part of the Saharanpur city and it joins the Hindan river near the village the Nandi. Near the village Pitlokhra it is joined by the West Kali *nadi*, which is seasonal stream, but attains considerable proportion during the wet monsoon months. In its upper course it has two branches in Saharanpur district, both of which are known by the same name, i.e., "West Kali *nadi*"[24]. Further south, West Kali *nadi* is joined by the Shila and Imlia drains on the left and right bank respectively. Passing through the district of Muzaffarnagar, it merges into the Hindan river. The width of the West Kali *nadi* in its southern part at the time of flood increases upto 100 yards in width and 20 feet in depth. On entering the district of Meerut the Hindan adopts a westerly course for about 16 km. where it is joined by the Kirsani *nadi*, the stream of Kirsani (called as Korsuni in its upper course) rises from the south of the city of Saharanpur and crossing the plain of Muzaffarnagar district, joins the Hindan to the east of village Malmajra in the district of Meerut.

The East Kali *Nadi*

The East Kali *nadi* is the main stream of the eastern part of Upper Ganga-Yamuna Doab. It rises from the lowlying depressions in the southeastern part of the district of Muzaffarnagar, and flows in and ill-defined channel until it enters into Meerut district.

Further south, in the district of Bulandshahr it is joined by a minor drain known as Abu-*Nala*. The drain of Abu-*Nala* was excavated in 1869 AD with the object of bringing water from the Hindan river to irrigate the pargana of Meerut. The *Nala*, for the present, however, serves a useful purpose in draining all the surplus water of the neighbouring areas into the east Kali-*nadi*. Traversing the district of Bulandshahr, the east Kali-*Nadi* enters the district of Aligarh near the village Kalyanpur. The width of the stream varies from about 300 yards in the rainy season to 50 yards in the dry season.

The Nim Nadi

In between the Ganga and the east Kali *nadi* in the district of Bulandshahr there is a stream known as Nim-*nadi*. On its right bank near the town of Dibai it is joined by a minor stream locally known as khallah. The width of the course of the Nim-*nadi* after its confluence with other drains increases appreciably. Then it makes a loop in the southern part of the district of Bulandshahr and passes into Aligarh district near the village Dharampur.

In addition to these channels, there are two minor drains called Patwaha-*nadi* and Karwan-*nadi*. These develop in the plain of Bulandshahr district and pass into the district of Aligarh at the villages of Deorar and Ramgarh respectively.

Lakes

Lakes are not an important feature in the surface drainage of the bhangar land of Upper Ganga-Yamuna Doab. In the khadar of the Ganga and the Yamuna, there are, however, lakes, which have originated on account of the meandering action of the rivers (Figure 2.5). These lakes are small in size and remain connected with these rivers by small channels.

Physical Divisions

On the basis of relief and drainage the area can be divided into the following divisions (Figure 2.6)

1. The Submontane Tract
2. The Hindan – Yamuna Interfluve
3. The Kali-Ganga Interfluve
4. The Hindan-Kali Interfluve
5. The Khadar

1. The Submontane Tract

The Siwalik Hills lie along the northern border of the district of Saharanpur. The hilly tract lying between the gorges of the Yamuna and the Ganga covers about 74 km. In the south of the Siwalik hills lie the submontane tract, locally called as *Ghar* which corresponds to the bhabar of the eastern Uttar Pradesh. Numerous seasonal streams intersect the tract of varying width. The stream of the east and central parts flow into the Ganga, while those of the west join the Yamuna river. The eastern part of the tract consists of a series of broken spurs and plateaus, which sink abruptly in the plain.

Fertile river valleys separate the submontane tract from the plain of Upper Ganga-Yamuna Doab. The water table in the area is extremely deep which renders the construction of wells difficult and expensive. From the agricultural point of view the area is backward and woods and shrubs cover its large parts.

2. The Hindan-Yamuna Interfluve

In the east of the Yamuna khadar the land is more stable and is not liable to floods except in the Yamuna and Hindan valleys. This stable zone covers the western part of the districts of Saharan-

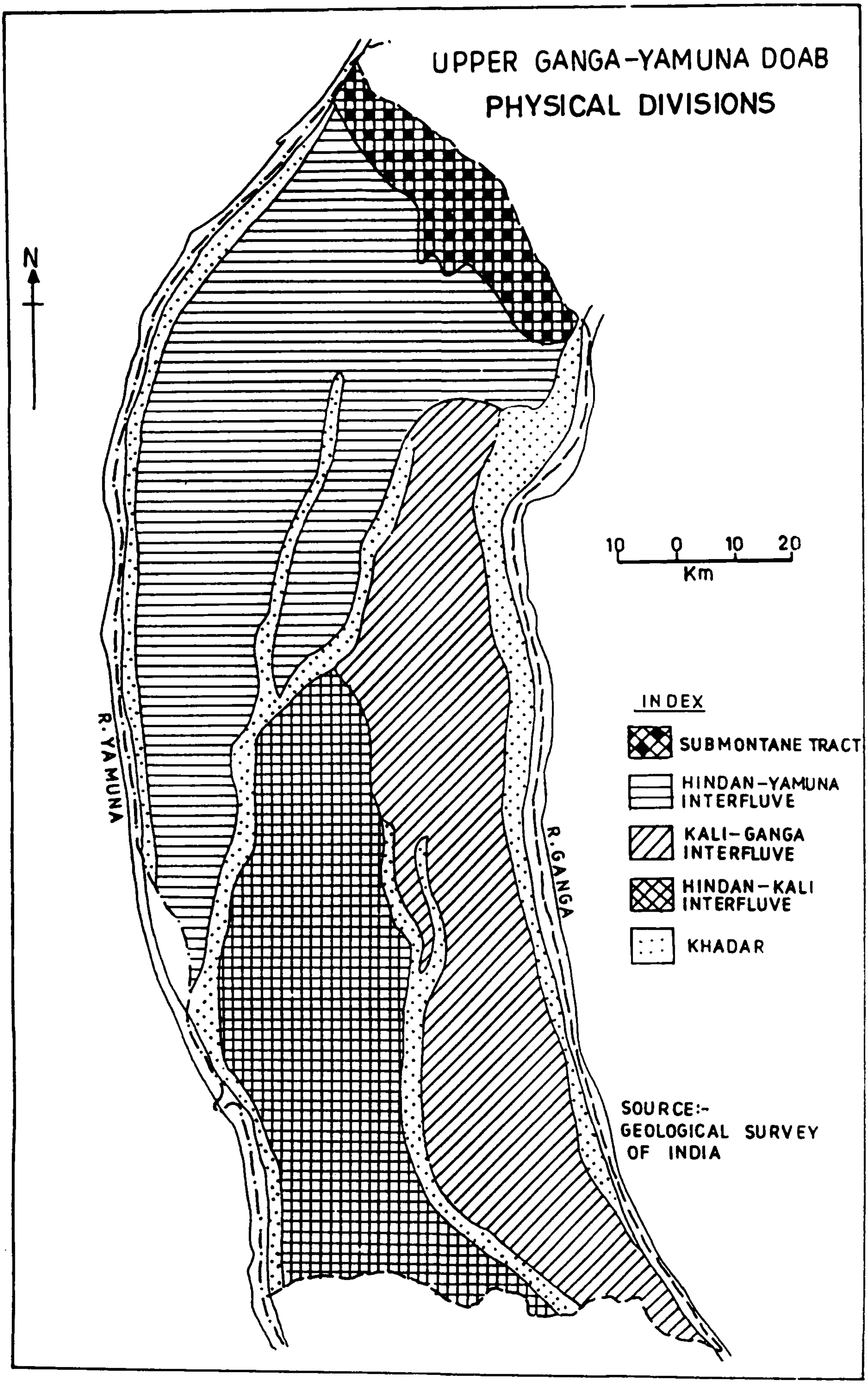

UPPER GANGA-YAMUNA DOAB
PHYSICAL DIVISIONS
N
10 0 10 20
Km
INDEX
SUBMONTANE TRACT
HINDAN-YAMUNA INTERFLUVE
KALI-GANGA INTERFLUVE
HINDAN-KALI INTERFLUVE
KHADAR
R. YAMUNA
R. GANGA
SOURCE:-
GEOLOGICAL SURVEY OF INDIA

Fig. 2.6

pur and Muzaffarnagar, the whole Baghpat and Sardhana tehsils, and considerable parts of the Meerut and Ghaziabad tehsils. The Yamuna-Hindan interfluve is extensively irrigated by the distributaries of the Eastern-Yamuna and Upper Ganga Canals. The water table varies between 25 and 35 feet.

3. The Kali-Ganga Interfluve

This tract stretches between the Ganga and the Kali *nadi* and includes the south eastern part of the district of Saharanpur and the whole of Jansath, Mawana and Anupshahr tehsils. The notable feature of this zone is the occurrence of sandy undulations locally called as *Ghur*. These sandy undulations start from the south of the Roorkee railway station and continues throughout the Ganga-Kali interfluve. The accumulation of sands rises to more than 15 feet except near Roorkee where the height is about 25 feet. The width, no where exceeds to 100 feet. The water table on the relatively elevated parts ranged from 25 to 40 feet and in the level parts from 15 to 25 feet.

4. The Hindan-Kali Interfluve

The East Kali-Hindan interfluve is relatively a lowlying ill-drained area. This tract includes the central part of the district of Meerut and greater part of the district of Bulandshahr. The distinguishing feature of the area is the lack of drainage. The soil varies from clay to sandy clay in the relatively elevated parts and clay to stiff clay in the depressions. The formation of Alkaline, *usar* soil, arising from the bad drainage is another characteristic of the area. Water table varies between 15 and 30 feet.

5. The Khadar

Khadar occupies a tract of varying width along the rivers Ganga, Yamuna and Hindan. The soil of the khadar varies from pure sand along the riverbanks to silty and silty clay in the valley of the rivers. The soil, however, is immature. The colour varies from light to ash gray and the texture is sandy and silty loam. The water table is very high and during monsoon it remains virtually on the surface itself. The nearness of the ground water level brings about wide spread salt efflorescence. On the surface especially during the summer months when the salt comes up with capillary rise of sub-soil water and its subsequent evaporation[25]. The drainage is imperfect and there is no natural flow of ground waters either laterally or downward because the water table is within a few feet of the surface. Almost every year in the months of July and August, the khadar parts of the plain are submerged under water and kharif crop is usually vulnerable to floods, but wherever cultivation is possible the soils are fertile. Another outstanding characteristic of the khadar is its great dependence on river action. The surface of the Ganga khadar is characterised by the presence of swamps and ox-bow lakes (Figure 2.6). Cultivation of melons and vegetables is the traditional practice of the people in the sands of the rivers

Soils

There is a lack of scientific data on the soils of Upper Ganga-Yamuna Doab. The oldest sources of available information are the Settlement Reports and District Gazetteers, both of which give a textural classification of soils arrived at by empirical methods for revenue assessment purposes[26]. The main factors governing the system of classification were texture, colour, availability of water and the level of the land[27]. The soil maps of India prepared from time to time by various authorities give only a general picture of the soils of Upper Ganga-Yamuna Doab[28], soil fertility survey, have not been initiated in Upper Ganga-Yamuna Doab[29]. And therefore, soil analysis data are not available for any of the districts of Saharanpur, Muzaffarnagar, Meerut, Bulandshahr and Ghaziabad.

The soils of Upper Ganga-Yamuna Doab are uniform in their characters. Nevertheless, several varieties of soils are recognised by the people, though the course, in no case any hard and fast line of demarcation can be drawn between one soil and the other. Each types of soil is given a local name. These local names are even now generally accepted throughout the Upper Ganga-Yamuna Doab, although in some cases a particular type of soil is known by different names in different districts.

During the course of field work of author, visited a number of villages in different parts of Upper Ganga-Yamuna Doab and obtained information on the soil characteristics, availability of water supply and manures, and on the level of the land. On the basis of this and another existing information, author has attempted a classification of the soil of the Upper Ganga-Yamuna Doab, and has drawn a soil map of the area, showing the classification and distribution of soils (Figure 2.7).

The soils of Upper Ganga-Yamuna Doab are alluvial and on geological basis fall in two divisions: the new alluvium and the old alluvium, also known as '*khadar*' and '*bhangar*' respectively. The khadar lands are found in the valleys of the Ganga, the Yamuna, the Hindan and their tributaries. The bhangar soil varies from gray-brown to dark brown in colour and sandy loam to stiff clay depending upon the topography and drainage. The occurrence of nodules locally known as *kankar*, which are found at various depths, is a significant characteristic feature of these soils.

Khadar or Sandy Soils

Nearly eighty percent of Upper Ganga-Yamuna Doab consists of the new alluvial deposits of the rivers. The soil of the khadar is markedly sandy adjacent to the river banks, but away from these banks in the valleys of the rivers it is sandy-silty and becomes

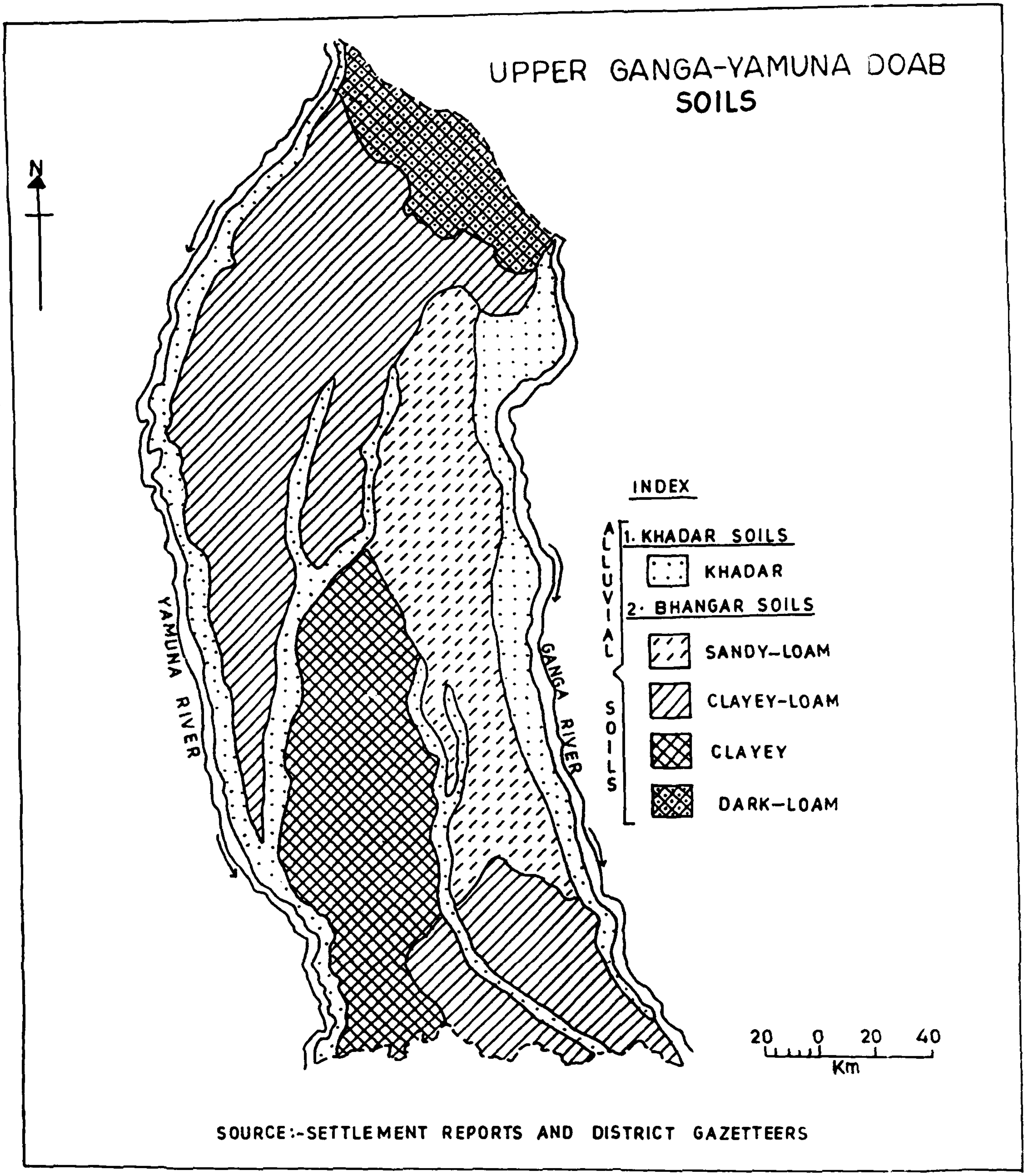

UPPER GANGA-YAMUNA DOAB
SOILS
N
INDEX
ALLUVIAL SOILS
1. KHADAR SOILS
KHADAR
2. BHANGAR SOILS
SANDY-LOAM
CLAYEY-LOAM
CLAYEY
DARK-LOAM
YAMUNA RIVER
GANGA RIVER
20 0 20 40
Km
SOURCE:-SETTLEMENT REPORTS AND DISTRICT GAZETTEERS

Fig. 2.7

silty-clay in the depressions. The relatively elevated sandy parts are devoted to maize, millets and sugarcane, while silty-clay is devoted to coarse varieties of rice, barley, wheat, lentil and peas mixed with gram and oat. Agriculture in this area is precarious due to waterlogging and floods. In the khadar some areas may be improved by deep opening ditches to serve as drainage lines provided there is sufficient gradient to allow for the rapid removal of drainage waters from the sub-soil.

Bhangar Soil

(i) Dark Loam (*Misan*)

The land between the streams of the submontane tract (*ghar*) consists of the dark loamy soil. Grass and shrubs mostly cover the thin layer of the soil resting on a substratum of stones and boulders. There are, however, numerous torrents in this area, which quickly drain off the rainwater and lead to soil erosion. In many parts, the underneath structure has been exposed by the erosive action of these torrents. The cultivated areas unaffected by erosion are, however, very productive maize, millets, groundnuts, rice, cotton and sugarcane in the kharif and wheat mixed with gram, peas and barley in the rabi season are generally sown.

(ii) Sandy Loam (*Raunsli*)[30]

In the Ganga-Kali interfluve the dominant soil is sandy loam. The surface soil is yellow to brown in colour, with a sub-soil, which is brownish yellow. The sub-soil is locally known as *sankrail*. Owing to the coarse and light texture of the soil, its water retaining capacity is low, but the irrigation facilities by the Upper Ganga Canal and tube wells have made it capable of producing good crops of sugarcane in the *kharif* and wheat in the *rabi* season.

(iii) Clayey Loam (*Seota*)[31]

The well drained Hindan-Yamuna interfluve is covered by clayey loam soil. As compared to *raunsli* soil, it is rich in clay and its water retaining capacity is high. The surface soil is brown to dark brown in colour, while dark gray in the lower horizon. Salt contents in this soil are low .In fact some of the highest crop yields in the area are found in this soil type. The clayey loam tract is extensively irrigated by the Eastern Yamuna Canal, Upper Ganga Canal and tube wells. Sugarcane, rice, maize and fodder are the principal crops cultivated in the kharif season, while wheat, gram, peas and barley are mainly cultivated in the rabi season.

(iv) Clayey Soil (*Chikkan, Dakar*)

The Yamuna-Hindan interfluve is covered by soils varying from sandy clay to clayey. The surface soil is grey to dark grey in colour, with a sub soil, which is dark brown. The *chikkan* soils are rather very hard and very difficult to plough, specially when it becomes dry. When the wet soil gets puddled up and becomes sticky. Whenever the salts occur in large proportions the land is not used for cultivation. The relatively elevated parts where the soil is sandy clay are devoted to maize, millets and sugarcane, while in the lowlying parts rice is the main crop in the kharif. In the rabi season, wheat, gram, peas are grown.

In the lowlying areas of clayey soil in the years of low rainfall weeds viz.,, *kans, phoos* and *kasair* flourish, and render the ploughing of land difficult.

Irrigation

Upper Ganga-Yamuna Doab with exceptions of the submontane and khadar tracts is well irrigated. In the submontane tract the deep water table and underlying rocky structure renders the construction of wells difficult and the steep gradient obstructs the development of canal, while in the khadar, owing to the high water table, the sub soil remains almost saturated and irrigation to the crops is generally not required.

Irrigation maps of Upper Ganga-Yamuna Doab have been prepared from time to time by the Canal and Tube well Department. But these maps do not show the areas irrigated by indigenous methods (viz., *rahat* , *ponds* and *streams*)[32] (Figure 2.8).

The major sources of irrigation in Upper Ganga-Yamuna Doab are:

i The Canals, and

ii The Wells

I. Canal Irrigation

Canals constitute the main source of irrigation in the area. Nearly, 1776000 acres or about 50 percent of the total cultivated land is under their command[33]. The total length of the main canals and their important distributaries is about 4827 km. in the area under review (Figure 2.8).

The principal canals in the area are:

i The Eastern Yamuna Canal,

ii The Upper Ganga Canal, and

iii The Lower Ganga Canal.

The Eastern Yamuna Canal

The Eastern Yamuna Canal is one of the oldest irrigation works in India. It was taken out in 1830 AD from the left bank of the Yamuna river, by constructing a dam across the courses of the river, at the town of Faizabad in the northwestern corner of Saharanpur distinct. The volume of the water in the Yamuna increases by the middle of March, When the melting of snow takes place. In the hot weather months about 6,500 cusses of water is

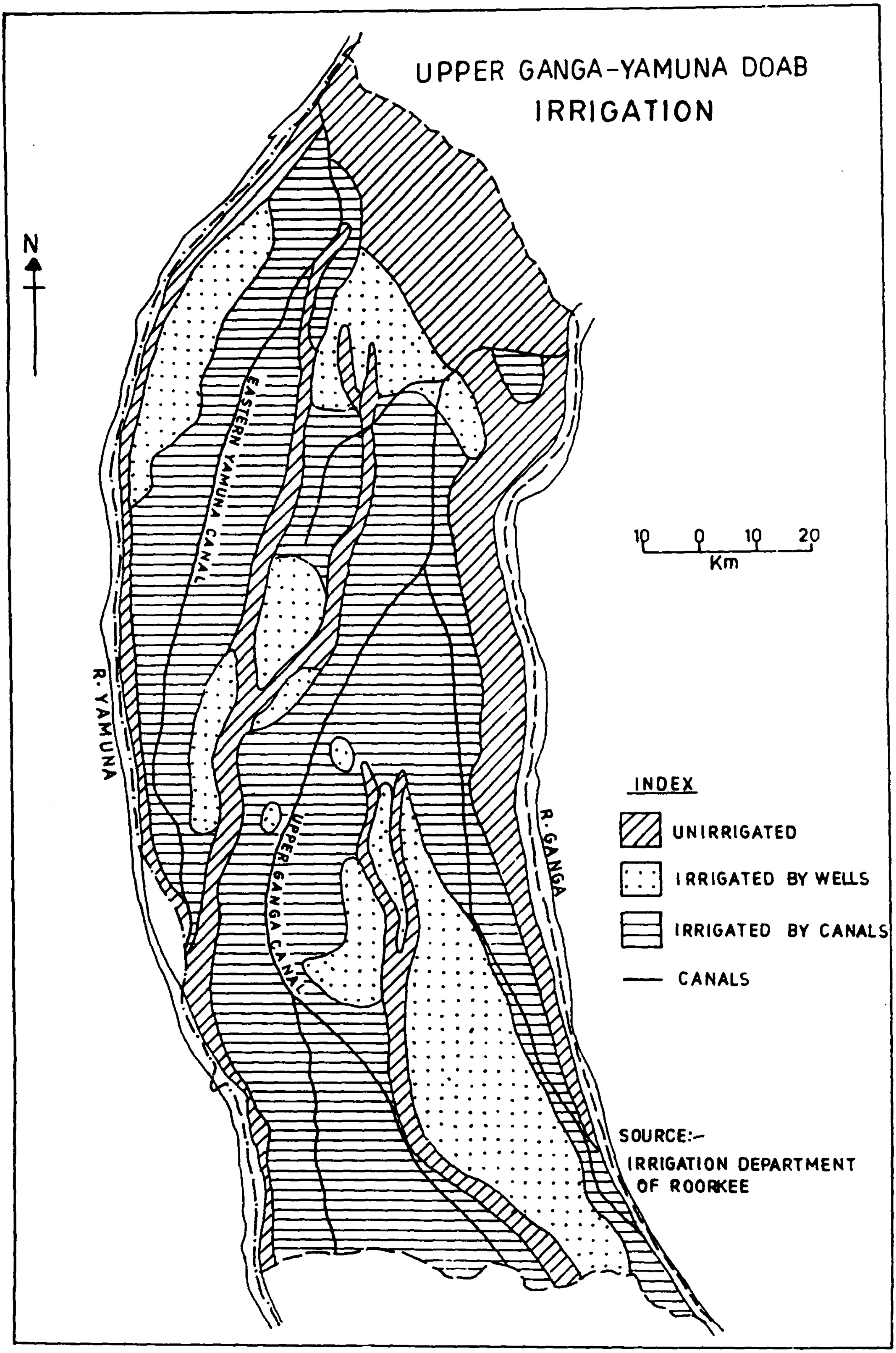

UPPER GANGA-YAMUNA DOAB
IRRIGATION
N
EASTERN YAMUNA CANAL
UPPER GANGA CANAL
R. YAMUNA
R. GANGA
10 0 10 20
Km
INDEX
UNIRRIGATED
IRRIGATED BY WELLS
IRRIGATED BY CANALS
CANALS
SOURCE:-
IRRIGATION DEPARTMENT
OF ROORKEE

Fig. 2.8

discharged in it. While in the cold weather season when, the volume of water in the river frequently falls below 3,000 cusses, less than 1200 cusses are discharged in the canal.

The upper part of the canal flows in southeasterly direction. Several important irrigation works viz., Raipur, Gandewad and Behat minors have been excavated from the right bank of canal. Irrigation from these minors is provided to about 2,500 acres of land lying in the north of Maskara torrents. The beds of hilly torrents and the underlying rocky structure are the main difficulties in the extension of irrigation channels in this area.

The canal enters the district of Muzaffarnagar after traversing a distance of 89 km. from its headwork. On entering the district of Muzaffarnagar it bends towards southwest. A number of distributaries and minors have been excavated, in this district from the right and the left banks of the canal among which the Kairana and Kandhla are important. The canal enters the district of Meerut at the village Nala. In Meerut district the volume of water in the canal decreases considerably and the canal, has therefore, been divided into a net of distributaries and minors, among which, the Nala , Bijwara, Fazelpur, Idrispur, Daula and Multi are important . The canal finally meets the Yamuna River in the southwest corner of Meerut district (Figure 2.9).

One general complaint against the canal irrigation in the area irrigated by the Eastern Yamuna canal is that in the canal water supplies are inadequate in hot weather months when irrigation is most needed for the sugarcane and fodder crops. Any scheme to increase the volume of discharge in the canal shall be helpful in overcoming the problem.

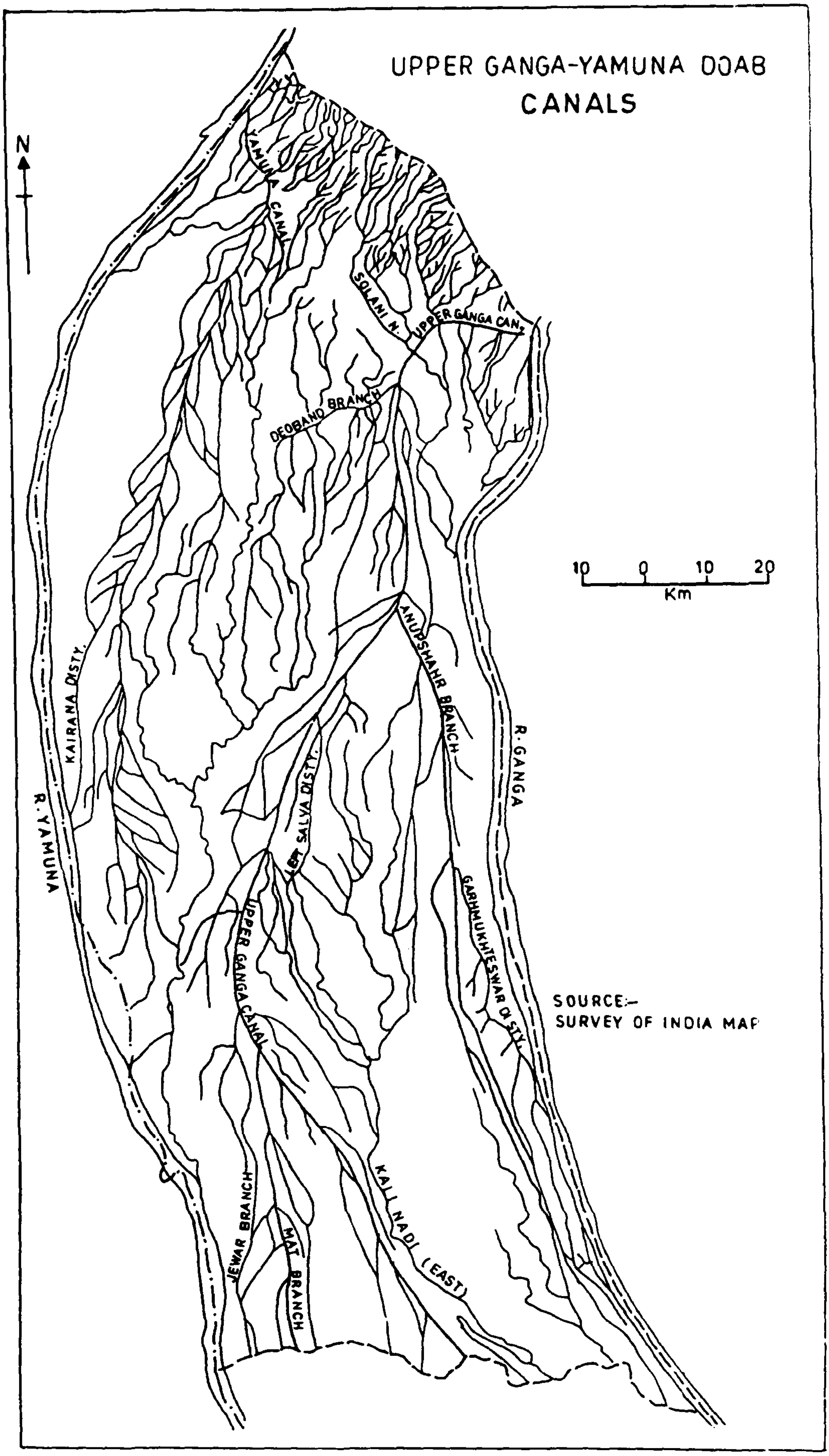

UPPER GANGA-YAMUNA DOAB
CANALS
N
YAMUNA CANAL
SOLANI N.
UPPER GANGA CAN.
DEOBAND BRANCH
10 0 10 20
Km
ANUPSHAHR BRANCH
KAIRANA DISTY.
R. GANGA
R. YAMUNA
GARHMUKHTESWAR DISTY.
UPPER GANGA CANAL
SOURCE:-
SURVEY OF INDIA MAP
JEWAR BRANCH
MAT BRANCH
KALI NADI (EAST)

Fig. 2.9

The Upper Ganga Canal

The Upper Ganga Canal was drawn off in 1853AD from the right bank of the Ganga by constructing a dam across the course of the river. The total length of the main canal in Upper Ganga-Yamuna Doab is 249 km., which commands about 1121800 acres or 43 percent of the total irrigated land[34]. The slope of the canal from Hardwar to Aligarh is 120 feet, broken into 13 vertical falls of eight to twelve feet. Some of these falls have been utilized for generating electricity.

From Hardwar the canal takes a westerly course. At a distance of 1.5 km. from Hardwar, the kankhal minor has been taken off. Near the town of Jawalapur, it crosses the Raipur stream by a super-passage, with a waterway of 200 feet. After passing the Raipur stream, the canal gives off the Ibrahimpur and Bahadrabad minor. These irrigation works provide water to the land, lying on the left bank of the canal. But the Ganga khader, which stretches to their south and in which irrigation is generally not required, limits the southward extension of these minors. In the 15 km. and 32 km. the canal has been carried over the Pathri and Ratmau torrents respectively.

The Deoband Branch

About 5 km. to the south of Roorkee the canal discharges appreciable volume of water in the Deoband branch which has been drawn off from the right bank. It was previously known as the Right Main distributary of the Upper Ganga Canal. In 1876 AD a project for remodelling the Right Main distributary through the west Kali *nadi*-Hindan interfluve was proposed. The undertaking was completed in 1876 AD and the name was changed from the Right Main distributary to the Deoband branch of the Upper Ganga Canal.

The present channel of this branch is about 50 feet in width and carries an initial discharge of 500 cusses.

Moving westward, it gives off the Sindhauli distributary which irrigates the land stretching between the Sila-*nala*[25] and the West Kali-*nadi*. On the 19 km. the Deoband branch has been carried over the west Kali-*nadi* with the help of an aqueduct, which enables the canal to enter the relatively elevated plain of the Kali-Hindan interflux.

Two furlongs in the south of the Deoband branch is the headworks of the Left Main distributary (also known as Manglaur distributary). It flows almost parallel to the main canal for a distance of 16 km. in the district of Saharanpur and Muzaffarnagar, and providing water to about 7,000 acres of land. In both the districts wheat and sugarcane are major crops irrigated by this distributary. Flowing due southward on its way to Jauli, the canal gives off the Mohammadpur and Basera distributaries from the right bank.

The Anupshahr Branch

Anupshahr branch formally known as the Fatehgarh branch of the Upper Ganga Canal was excavated in 1871 AD to provide water facilities to the land lying between the Jauli town and Fatehgarh (Farrukhabad). Later on, the name was changed when it was found that supplies in the canal to the south of Anupshahr town are not adequate. The introduction of this branch of the Upper Ganga Canal has, however, ensured the cultivation of crops in the sandy loam tract of the Upper Ganga-Yamuna Doab.

A number of distributaries and minors have been taken off from the left and right banks of the canal, among which Parichhatgarh, Garhmukteswar, Kithor, Talwar and Ghusrana are significant. Part of the town of Jauli, the main canal towards southwest and before entering the district of Meerut, discharges appreciable volume of water into the Daurala and Salwa distributaries. In the southern part of Meerut it makes a curve and then bends towards southeast.

Mat Branch

The main canal before passing into the district of Bulandshahr discharges 350 cusses in the Mat branch. This branch was excavated in 1860 AD with an initial discharge of 250 cusses, but now it carries about 350 cusses. Passing due southward the Mat branch gives of Barauda and Basupur distributaries from the left bank at the Kot village, which irrigate about 4,500 acres. Further south at Sunphera village is the source of Jwar distributary, which in turn has been divided into minors, and thus, provides water in the southwestern corner of Bulandshahr district.

The Lower Ganga Canal [36]

This canal was excavated in 1878 AD by constructing a dam across the course of the Ganga at the Naraura village. It was initiated with an initial discharge of 3,500 cubic feet per second in the cold weather and 6,500 cubic feet per second in the season of general rains.[37] It traverses the southeastern corner of Bulandshahr district along the right bank of the Ganga.

II. Well Irrigation

Well irrigation can be divided under two heads (i) Wells and (ii) Tube-wells.

The well irrigation is an important and indigenous method in Upper Ganga-Yamuna Doab. It is well suited to the poor farmers, because its construction is simple and cheap, and it requires no extensive machinery in its operation. As well as irrigation, entails more labour on the part of the cultivators for raising water from varying depths, the farmers are careful and use water economically.

Tube-wells which are comparatively of recent development in Upper Ganga-Yamuna Doab are the major sources of irrigation in those tracts of the plain, where owing to the high and undulating level of the land, irrigation by canals is not possible. The area is therefore, irrigated by tube wells.

After utilising the waters of the Ganga and the Yamuna rivers, it was realised by the irrigation authorities that further extension of canal distributaries within the area was not possible. And successful cultivation of crops could not be ensured in the unirrigated areas, unless facilities were available for watering crops, whenever needed.[38]

In Upper Ganga-Yamuna Doab, tube-wells are generally drilled at an average depth of 260 feet. The average discharge from such a tube-well equipped with a six inch stainer is about 31,000 gallons per hour which can irrigate nearly half of an acre of sugarcane in the months of April and May.

Effects of Canal and Well Irrigation

The economic effects of the development of canals and wells on agriculture, cropping pattern, land use and occupation of the people are considerable in Upper Ganga-Yamuna Doab, where rainfall is most variable. The provisions of irrigation by canals, the tube wells in the area have averted the total failure of crops during droughts period.

Increase in irrigated land has been a boon to the cultivators is not only for increasing the extension of cultivation, but also for increasing the output per acre.

The indirect advantage arising from the canals are that in the months of May and June, when ponds (the main source of water supply of cattle) dry up, they can be filled without any payment.

Canal irrigation is nevertheless faced by several setbacks, which have direct adverse affects on the use of land. Excessive irrigation which is a common practice in the canal irrigation tracts reduces the fertility of soil and adversely affects the output of the crop.

The extension of canal distributaries and irrigation channels in Upper Ganga-Yamuna Doab has obstructed the natural drainage and has raised the water table[39]. The elevated water table and chemical variations of the ground and canal waters have been considered, as the main cause of Alkaline and *reh* formations in the district of Upper Ganga-Yamuna Doab[40]. Moreover, the water logging resulting from over watering and a subsequent rise in water table has led to the formation of salt efflorescence and rendered acres unsuitable for the growing of crops. Moreover, areas with canal irrigation have shown susceptibilities to encourage malaria with its harmful effect on the health of the villagers and this adversely affects the efficiency of the villagers [41]. The solution of the problem lies in the development of natural drainage. Cultivators should be prevented from over irrigation of crops and demonstration should be made, about the suitable and economic utilization of canal water.

The tube-well irrigation is a flexible method as the wells can be drilled in areas of productive soil. Further, owing to the volumetric sale of water in tube-well irrigation the cultivator is financially interested in reducing the minimum wastage of water between the well and the fields. A secondary advantage is that when water for drinking purposes is required by the villagers, it is healthy and free from germs of diseases.[42].

It is true that the extension of canals and drilling of tube wells to a great extent have assured the cultivation of crops in Upper Ganga-Yamuna Doab. But it appears necessary to disseminate scientific knowledge about the use of water for irrigation purpose.

Climate

The climate of Upper Ganga-Yamuna Doab is characterised by seasonal rhythm, which is produced by the southwest and northeast monsoons. The reversal of the prevailing winds takes place regularly twice in the course of year. In one part of the year the winds are of continental origin and blow from north east to south-west, while in the other part they are oceanic and blow from south west to north east. In view of the nature and directions of the winds, the terms wet monsoon and dry monsoon are appropriate.

The dry monsoon lasts from December to the middle of June and can be divided into two periods: cold weather season and hot weather season. The cold weather season extends from December to February, while the hot weather season lasts from March to mid June.

The wet monsoon can also be divided into two periods: the season of general rains which extends from the middle of June till the end of September and the season of retreating monsoon which extends over the months of October and November (Figure 2.10).

Therefore, the climate of Ganga-Yamuna Doab is characterised by four distinct seasons:

1. the cold weather season (December to February);
2. the hot weather season (March to mid June);

3. the season of rains (mid June to September);
4. the season of retreating monsoon (October to November).

1. The Cold Weather Season

December and January are the coldest months, when the maximum and minimum temperatures are 21^0C and 6^0C respectively. The cold waves coming from the Himalayas also bring a fall in the temperature for short period. In February the temperature rises slightly. In these months heavy mist and fog locally known as *kohra* which often occurs at night and lasts until the sunrises. Occasionally, the fog becomes so intensive and prolonged that it damages the *rabi* crop (winter crop). During the month of December, January and February, a few depressions accompanied by moderate rainfall pass through this area. The rainfall decreases from northwest to southeast and the total amount of rainfall during the cold weather season, no where exceeds 10 cm. This rainfall, though, small in quantity is highly beneficial to the *rabi* crops as it comes at a time when plants are at the stage of flowering (Figure 2.11).

2. The Hot Weather Season

The hot weather season is characterised by rising temperature and falling pressure. At the advent of March, temperature starts rising and continues till the month of May and June. The maximum and minimum temperature for the month of April are 38^0C and 21^0C respectively. The month of May and June records exceptionally high temperature, as high as 44^0C and even more than 46^0C for few days. The days are characterised by intensive heat, dry air and low relative humidity. Regular phenomenon of this season is the blowing of hot and dry winds locally called as *'Loo'* and the occurrence of dust and thunderstorm which are locally known as *'Andhi'*. They usually occur in the afternoon and are accompanied

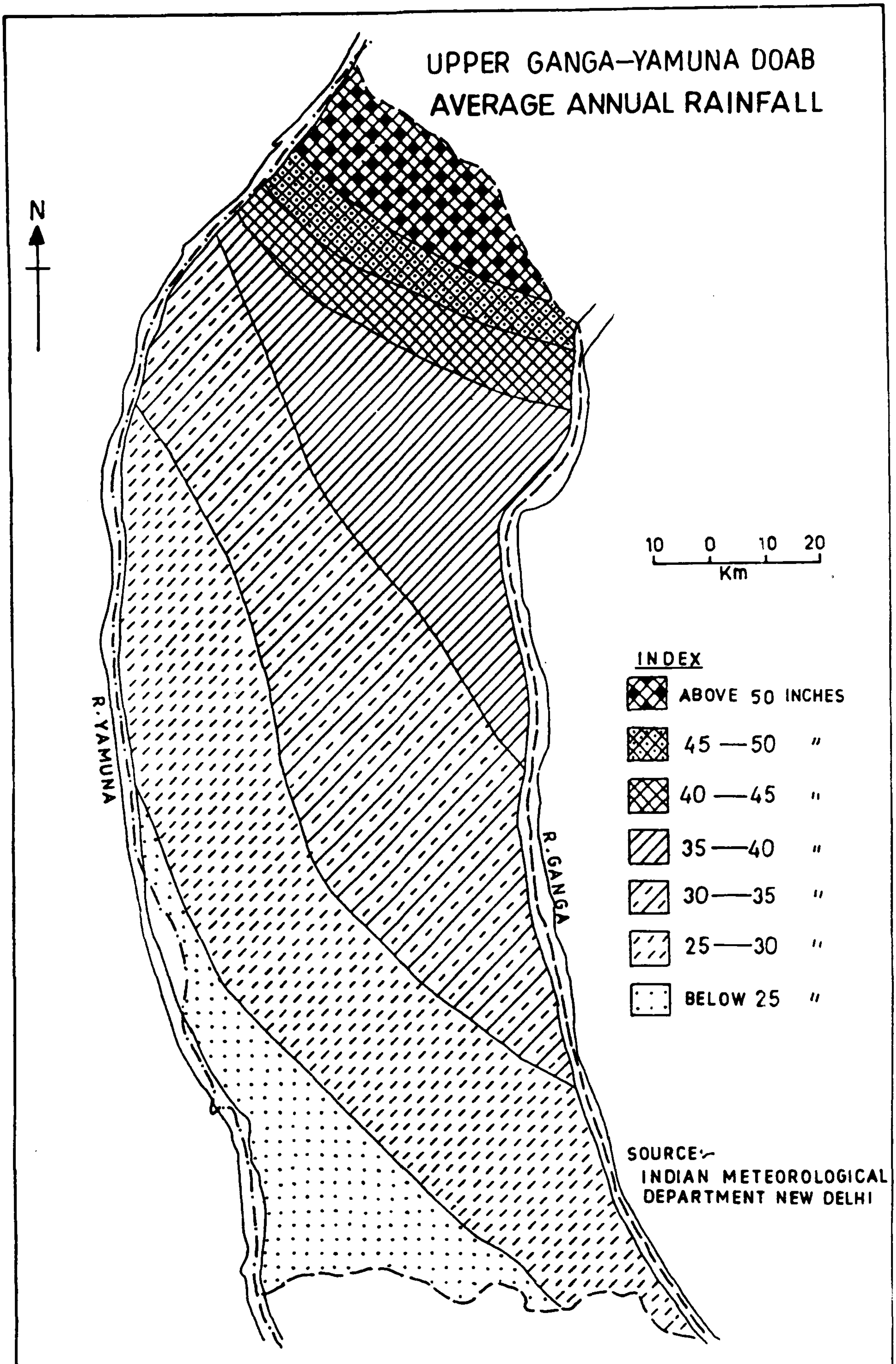

UPPER GANGA–YAMUNA DOAB
AVERAGE ANNUAL RAINFALL
N
10 0 10 20
Km
INDEX
ABOVE 50 INCHES
45 —50 "
40 —45 "
35—40 "
30—35 "
25—30 "
BELOW 25 "
R. YAMUNA
R. GANGA
SOURCE:-
INDIAN METEOROLOGICAL
DEPARTMENT NEW DELHI

Fig. 2.10

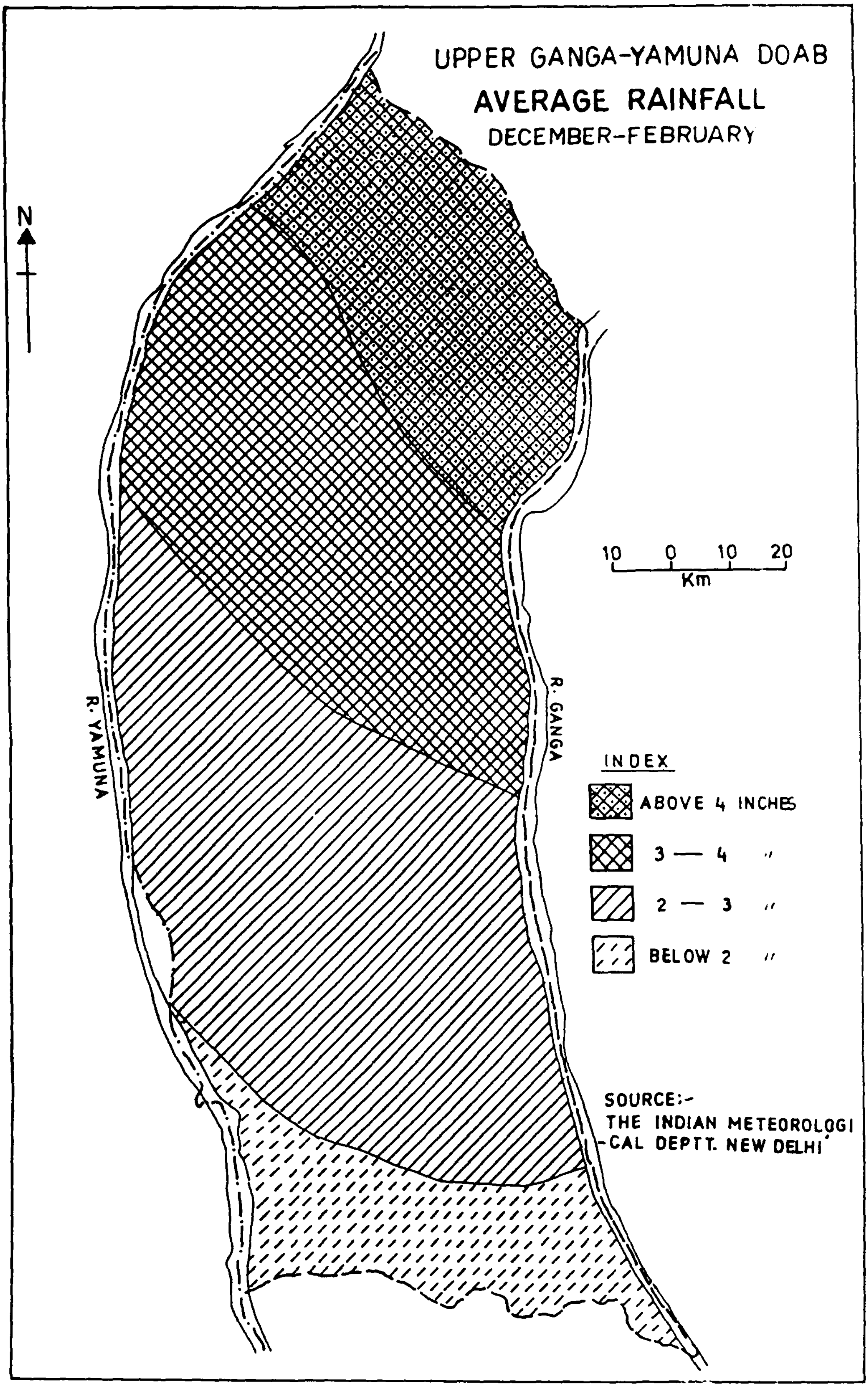

UPPER GANGA-YAMUNA DOAB
AVERAGE RAINFALL
DECEMBER-FEBRUARY
N
10 0 10 20
Km
R. YAMUNA
R. GANGA
INDEX
ABOVE 4 INCHES
3 — 4 "
2 — 3 "
BELOW 2 "
SOURCE:-
THE INDIAN METEOROLOGI
-CAL DEPTT. NEW DELHI

Fig. 2.11

by squally winds, thunder lightening dust and sometimes rains. The amount of rainfall during this period is very low and is not very important for agriculture.

3. The Season of General Rains

Monsoon normally commences in the first week of June and reach to the reigion in the beginning of the last quarter of the month of July. The advent of the monsoon brings a complete change in the weather. There is fall in the day temperature. The maximum and the minimum temperature gradually fall from 44^{0}C and 27^{0}C respectively in June to about 30^{0}C and 25^{0}C in July. The relative humidity remains over 70 percent, throughout the rainy season There are bursts of rain alternating with rainless intervals, which lasts for three to five days. The months of July and August are the rainiest months and receive more than 50 percent of the total rainfall. The relative humidity increases and is about 85 percent in August. In September the rains normally slacken and rainless intervals become longer. The relative humidity remains high. The rainfall decreases from southeast to northwest in the region (Figure 2.12).

4. The Season of Retreating Monsoon

The retreating monsoon starts during the month of October and remains upto the end of November. In October, the mean monthly temperature is 25^{0}C at Roorkee and 27^{0}C at Meerut. The mean maximum temperature of this month at Roorkee and Meerut are 35^{0}C and 33^{0}C respectively. While the mean maximum temperature for that month is 17.4^{0}C and 18^{0}C respectively. In November there is a further decrease in the mean monthly temperature, which is 20^{0}C at Roorkee and 21^{0}C at Meerut The relative humidity at Roorkee in October and November is 75 and 77 percent respectively. The total amount of rainfall in the months of retreating monsoon is less than 2.5 cm. at all the stations. The clear sky during this period is conducive for the growth of *rabi* crops (Figure 2.13).

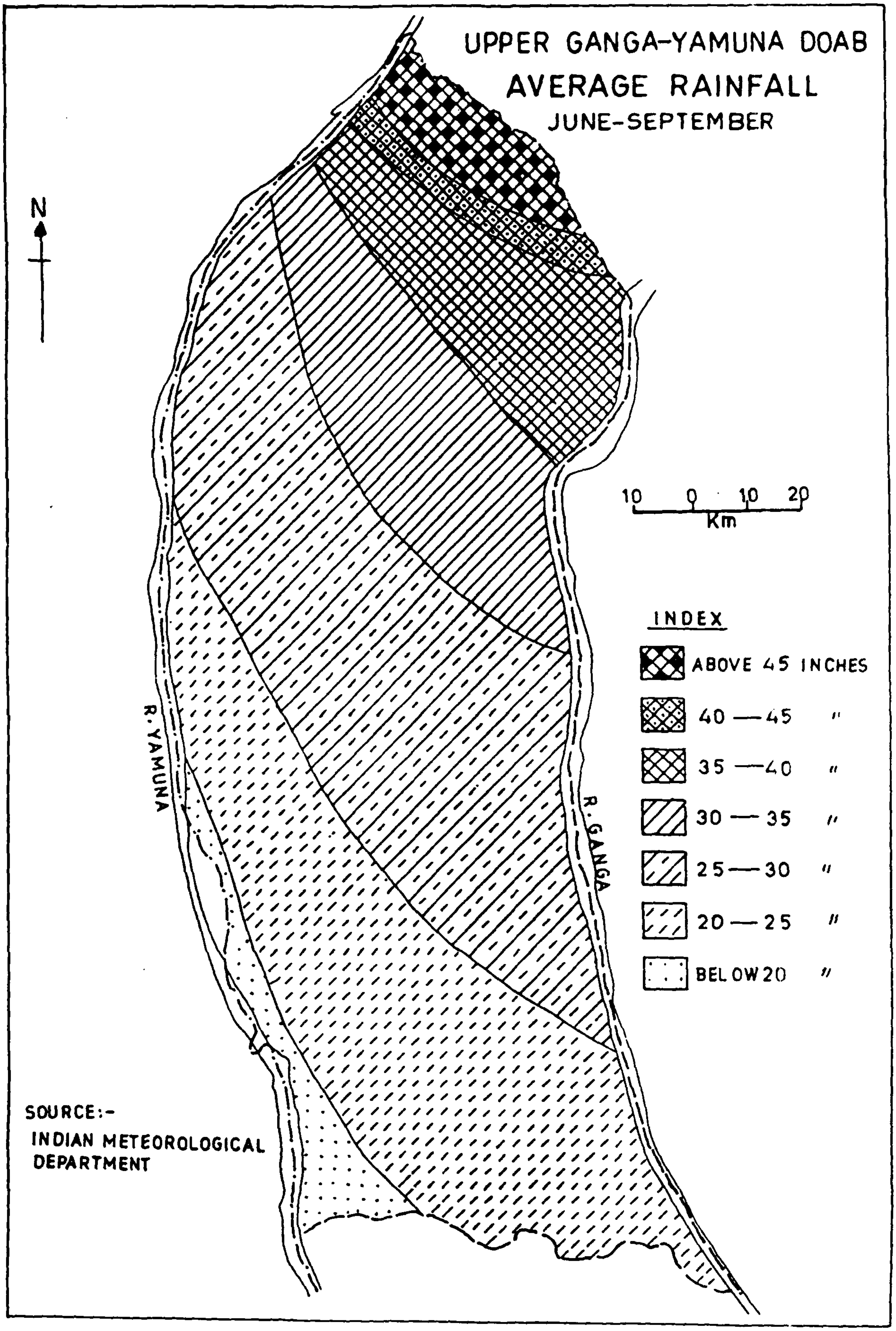

UPPER GANGA-YAMUNA DOAB
AVERAGE RAINFALL
JUNE-SEPTEMBER
N
10 0 10 20
Km
INDEX
ABOVE 45 INCHES
40 — 45 "
35 — 40 "
30 — 35 "
25 — 30 "
20 — 25 "
BELOW 20 "
R. YAMUNA
R. GANGA
SOURCE:-
INDIAN METEOROLOGICAL
DEPARTMENT

Fig. 2.12

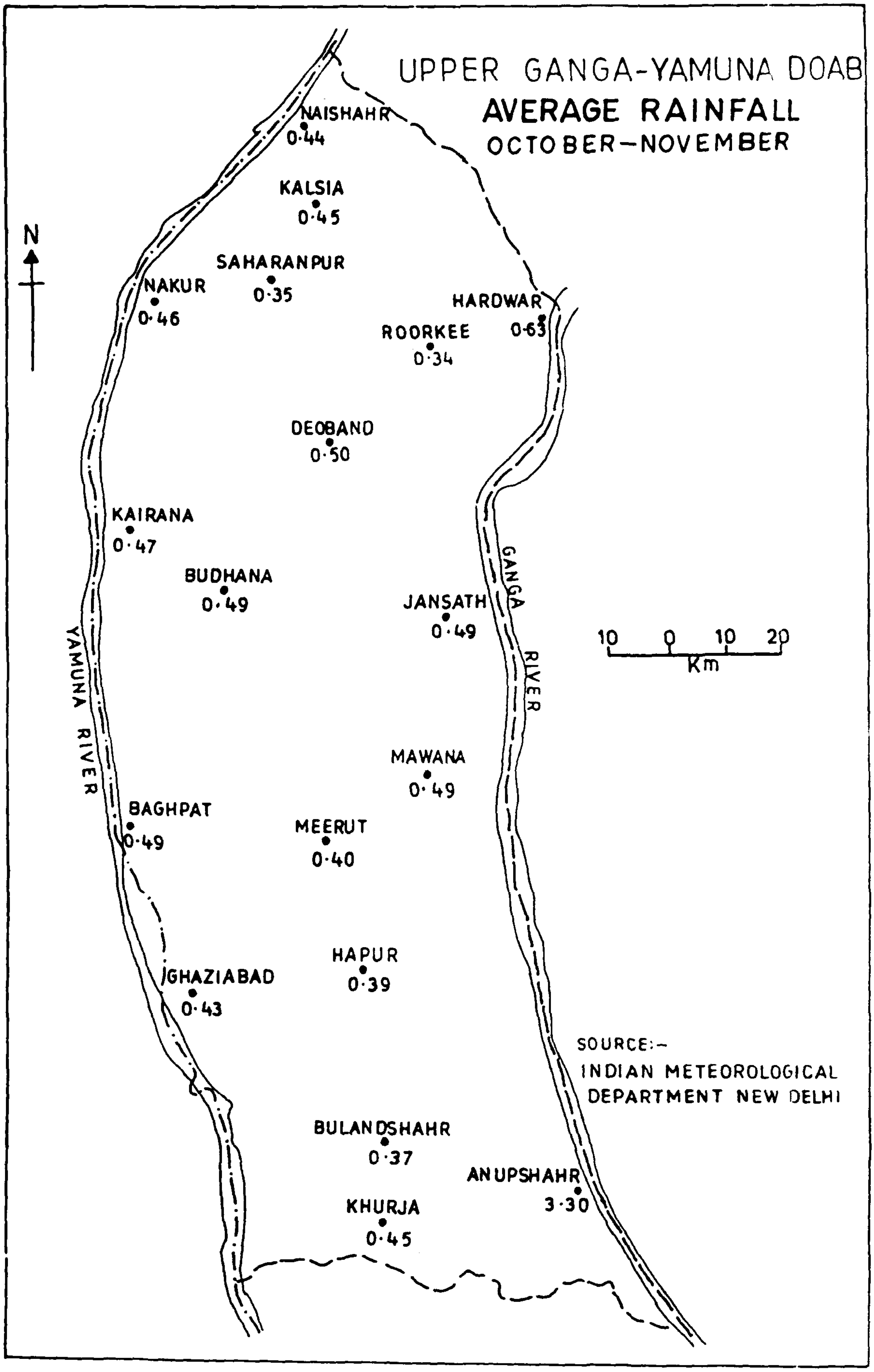

UPPER GANGA-YAMUNA DOAB
AVERAGE RAINFALL
OCTOBER-NOVEMBER
N
NAISHAHR 0·44
KALSIA 0·45
SAHARANPUR 0·35
NAKUR 0·46
HARDWAR 0·63
ROORKEE 0·34
DEOBAND 0·50
KAIRANA 0·47
BUDHANA 0·49
JANSATH 0·49
GANGA RIVER
YAMUNA RIVER
10 0 10 20
Km
MAWANA 0·49
BAGHPAT 0·49
MEERUT 0·40
HAPUR 0·39
GHAZIABAD 0·43
SOURCE:-
INDIAN METEOROLOGICAL
DEPARTMENT NEW DELHI
BULANDSHAHR 0·37
ANUPSHAHR 3·30
KHURJA 0·45

Fig. 2.13

DEMOGRAPHIC CHARACTERISTICS

A perusal Table 2.3a and 2.3b of demographic attributes clearly reveals the general picture of population growth, percentage of male and female, literacy rates, agriculture workers, scheduled cast and scheduled tribes of population of Upper Ganga-Yamuna Doab at district and tehsil level breakup from 1971 to 1991.

The rate of education in the process of development of a region is quite obvious. It is one of the chief instrument through which society, socialises its member and bring desirable changes in the social life of the people. Education infact, the aggregate of all the process by mean of which a person developability, attitude other forms of behaviour of positive values in the society in which he lives. It is a social process by which people are subjected to the influence of selected and controlled environment, so that they may attained social competent and optimum individual development. And as such, it may be said the education effluence the cause of behaviour of both society and its individuals. Since adoption behaviour of farmers is a learning process involving knowledge, attitude and skill regarding agricultural innovation, it can not be exception to be it. Several studied concluded in India and abroad regarding technological change and diffusion of agricultural innovations have proved the closed positive relationship between the rate adoption and literacy index. The educated farmers not only adopt agricultural innovations quickly but also in a better and more scientific way. Even in the traditional method of agriculture, he brings refinement and improvement, and eventually gets higher agricultural production.

India is basically a social country where the religious and social norms, values, traditions and customs play important role in all walks of life. And, agricultural productivity is no except to this

Table - 2.3a
Demographic Attributes of Upper Ganga-Yamuna Doab
District Wise from (1971-1991)

Districts	Total Population	Male	%age of Male Population	Female	%age of Female Population	Rural	Male	Female	Urban	Male	Female	Literacy age%			%age of Main Workers			%age of Agriculture Labour			Density of Population (per sq. Km.)	%age of S.C & S.T. Population					
																						e of S.C Pop.			%age of S.T. Population		
												Total	Male	Female	Total	Male	Female	Total	Male	Female		Total	Rural	Urban	Total	Rural	Urban
1971																											
Sharanpur	2054834	1128485	54.92	926349	45.08	1572027	859361	712666	482807	269124	213683	29.40	31.53	13.52	29.80	52.95	1.59	26.88	26.86	28.19	371	23.3	28.00	8.2	0.1	0.1	N
M.Nagar	1802289	984495	54.62	817794	45.48	1552474	849186	703284	249815	135309	114506	26.78	22.64	30.93	28.72	51.20	1.67	27.97	27.73	36.70	424	16.5	17.7	9.2	0.1	0.1	0.2
Meerut	3366953	1838552	54.6	1528404	45.4	2549967	1388700	1161267	816986	449852	367134	2711	38.21	16.01	27.57	49.11	1.67	16.32	16.29	17.02	565	17.8	19.5	12.5	0.1	N	0.2
Bulandshahr	2073343	1118441	53.94	954902	46.06	1796935	970355	826580	276408	148086	128322	20.99	32.81	9.16	26.72	48.27	1.51	17.51	17.42	21.02	424	20.5	21.8	12.3	N	N	0.3
1981																											
Sharanpur	2673561	1459421	54.59	1214140	45.41	1949442	1062473	886969	724119	396948	327171	27.54	36.90	18.36	29.23	52.17	1.63	28.45	28.41	29.91	498	22.02	26.97	8.71	0.01	0.02	0.0017
M.Nagar	2274487	1334213	54.26	1040274	45.74	1780502	969271	811231	493985	264942	229043	30.25	40.87	17.64	28.08	50.15	1.92	28.64	28.51	32.69	561	14.8	16.51	8.63	0.0093	0.0084	0.01
Meerut	2767246	1505712	54.41	1261534	45.59	1903280	1039614	863666	863966	466098	397868	34.68	46.73	20.30	27.67	48.93	2.34	18.94	18.91	19.70	708	16.77	18.75	13.44	0.0062	0.0062	0.005
Ghaziabad	1843130	1007460	54.66	835670	45.34	1214054	661643	552411	629076	345817	283259	35.28	48.68	21.32	25.74	46.86	1.59	18.09	18.00	21.18	542	19.69	21.32	16.51	0.0035	0.00042	0.0058
Bulandshahr	2358270	1265427	53.66	1092843	46.34	1902245	1022787	879458	456025	242640	213385	28.97	42.47	13.34	27.51	48.37	2.54	12.78	12.36	22.21	712	21.44	23.36	13.43	0.00076	0.0023	0.0021
1991																											
Sharanpur	2309029	1247258	54.01	1061775	45.99	1719377	931608	887769	589652	315646	274006	42.11	53.85	28.10	28.71	51.03	2.61	30.86	30.43	40.64	626	20.5	26.81	9.92	0.01	0.002	0.03
M.Nagar	2842543	1528634	53.78	1313909	46.22	2143313	1158388	985925	699230	371246	327984	44.00	56.63	29.12	29.99	50.77	5.89	31.15	29.70	45.66	709	14.04	15.66	9.07	0.0018	0.0021	0.00085
Meerut	3447912	1861742	54.00	1586170	46.00	2171355	1180533	990822	1276557	681209	595348	51.03	64.47	35.62	28.24	48.74	4.27	12.54	20.90	30.10	882	16.64	18.14	14.08	0.0023	N	0.0061
Ghaziabad	2703933	1476188	54.59	1227745	45.41	1455673	794425	661248	1248260	681763	566497	44.71	61.96	24.30	27.33	46.92	3.88	14.27	13.97	18.63	622	17.89	19.16	16.4	0.0055	0.0039	0.0073
Bulandshahr	2849859	1535572	53.88	1314287	4612	2257064	1220244	1036820	592795	315328	277467	55.22	68.64	38.81	26.73	46.70	3.64	21.86	21.40	28.68	1044	21.96	23.21	13.52	0.0043	0.0024	0.01

Table 2.3b
DEMOGRAPHIC SETTING OF UPPER GANGA-YAMUNA DOAB
TEHSIL WISE (1991)

Sr. No.	Name of Tehsil	Density of Population	%age of S.C. and S.T. in total population	%age of workers of total population	% of population engaged in Agriculture Workers	%age of Literacy		
						Total	Male	Female
1	Saharanpur	631.3	33.9	29.2	28.2	35.86	50.36	8.58
2	Nakur	447.9	21.4	30.1	50.0	31.96	47.97	19.19
3	Roorkee	449.8	21.4	30.2	38.2	29.46	40.74	15.97
4	Deoband	545.4	30.3	29.3	42.3	40.48	54.59	23.47
5	Kairana	528.4	12.9	31.4	77.6	38.7	52.6	21.90
6	Muzaffarnagar	620.5	19.2	30	75.1	40.2	53.6	24.40
7	Budhana	613.4	10.8	31	79.3	41.7	56.6	24.00
8	Jansath	486.4	18.4	31.5	78.0	41.9	52.3	26.00
9	Baghpat	685	12.9	29.8	73.8	46.86	62.33	27.98
10	Jarehana	588	17.8	28.9	73.6	47.03	62.16	28.75
11	Mavana	473	21.8	30.1	79.2	45.41	61.61	25.91
12	Meerut	694	22.5	28.8	67.8	46.13	61.15	27.26
13	Ghaziabad	733	21	26.00	50	52.5	68.8	32.80
14	Hapur	756.9	18.8	27.30	73.4	45	61	25.5
15	Garhmukteswar	641.6	19	27.5	78.5	40.3	56.3	21.2
16	Dadri	542	15.8	26.6	61.1	53.6	73.2	28.4
17	Sikandrabad	734	22.3	26.7	71.9	46.5	66.9	22
18	Bulandshahr	630	21.6	26.6	78	44.2	62.9	22
19	Anupshahr	485	21	26.9	84.4	37.3	55.3	45.8
20	Khurja	492	27.4	26.8	81.6	42.2	60.6	20.00

rule. The village people are very conscious to the social status. The social status of the people is generally, assessed by his caste, occupation, educational level, standard of living, family income, administrative position, political involvement, level of involvement and various socio-religious and political activities. It has been generally observed that the respondents of high social status are more liberal, open minded and receptive to agricultural innovations. All these factors obviously lead to high agricultural productivity. Therefore, in the present study it has also been hypothesis that there is positive relationship between the social status of the respondent and agricultural productivity.

The oriental agriculture societies are distinguished as feminists. The social organization and values and belief of the people, specially with developing country are centered around social institutions. In the rural area the families are almost in large in size and extended and joint in composition. The parent take their privilege with their son in the family. Family is the unit of social actions generally the head of the family takes the decision is all family matters. It has been found that in small family there is more immunity, cohensiveness, sprit of works and enthusiasm of becoming socio-economically better off. But in the large size of family in which spirit of works and enthusiasm, eagerness are lacks to progress socio–economically.

They are generally individualistic, and there are probability of different opinion on certain issues which may lead to grouping of different attitude of the member, It will finally effects the agricultural productivity. General observation is that there is inverse relationship in between the size of family and agricultural productivity.

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30. In the relatively elevated parts the soil is called *bhur*.

31. In the district of Saharanpur *Seota* is known as *doomat*.

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ii) Maps prepared by W. L. Stampe, *Published in the Ganga Valley State Tube Well Scheme*, showing the Tube Well areas the Main Grid Lines, plan I, II and III, Allahabad, 1936;

iii) Maps obtained from the Tube Well Department, Muzaffarnagar.

33. Information concerning the area irrigated and the volume of water discharged in the canals and their distributaries was obtained from the Roorkee, Saharanpur and Meerut Canal Division.

34. *Revised Project for the increasing Discharge Capacity of the Upper Ganga Canal*, Roorkee, 1948, p. 1.

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CHAPTER III

AGRICULTURAL DEVELOPMENT

AGRICULTURAL DEVELOPMENT

TECHNO-INSTITUTIONAL ADVANCEMENT IN AGRICULTURE: A SPATIO- TEMPORAL ANALYSIS

The history of adoption of new agricultural devices in agriculture of Upper Ganga-Yamuna Doab is very recent. It seems to appear in late 1960's, as most of the big landholders became more conscious toward adopting new agricultural technology, specially the adoption of machine, chemical fertilizer, HYV seeds etc. The marginal and small landholders adopted the new technology to lesser extent. Such adoptions are visible at all level even in the farming community of traditional society, despite socio-cultural and economic constraints. The technological change and spatial diffusion of agricultural innovations mainly depend upon economic condition, size of farms, irrigation facilities and literacy.

Hence, an attempt has been made to assess the regional variations and level of growth of technological adoption during 1970 to 1993. In order to make the data comparable the numerical informations have been arranged in tabulated form with the help of statistical computation. An emphasis has been made on the analysis of growth and pattern of irrigation, consumption of fertilizers, implements, pesticides etc. Irrigation has played crucial role directly and indirectly in promoting agricultural sector in general and raising yield of crops in particular. The practices adopted have been examined in terms of quantitative analysis per unit of gross cropped area to see its impact on agricultural productivity per unit of cropped area.

Pattern of Modern Agricultural Technology

Modern agricultural technology in the present context refers to practicing of developed agriculture devices like tractors, threshers, tube wells, pump sets, HYV, chemical fertilizers and other improved tools, which helps to bring radical changes in agricultural practices.

Tractor

Today, the role and importance of 'power' in agriculture is well understood. It has been seen through experience that, in India, about one million farmers have own tractors and another three million farmers depend on hiring facilities. Tractors have helped them, to raise agricultural production through timeliness of farm operation, performance of farm operations as per crop-husbandry practices, increase in productivity thereby enhancing their returns and savings. It strengthens rural transport of agricultural inputs and more importantly agricultural produce to the markets for timely sale. It is also a source of power in operating other machines like irrigation pumps, winnowers, threshers, sprayers etc.

The importance of farm mechanisation, in general, and utility of tractors, in particular, was felt by Indian farmers as early as 1920's. But, the real development took place during early sixties, when first tractor plant was set up in 1961. However, with the changing scenario of Indian agriculture, as it could be seen from Table and Figure 3.1, that there has been tremendous change in all the indicators listed, particularly after mid-sixties. All these development have been attributed to several factors, of which, farm mechanisation is one, in which tractorisation has completely changed the traditional approach of crop production. Thus, the demand for tractor has increased in the country. To meet the demand, domestic production of tractor has started in a big way.

Table 3.1
UPPER GANGA-YAMUNA DOAB
LEVEL OF MECHANISATION PER (,000) HECTARE
1972 - 1993

District	No. of Wooden Plough per ,000 Hectare	No. of Irom Plough per ,000 Hectare	No. of Cultivator per ,000 Hectare	No. of Disk Harrow per ,000 Hectare	No. of Diesel Pump per ,000 Hectare	No. of Electric Pump per ,000 Hectare	No. of Tractor per ,000 Hectare	No. of Thresure per ,000 Hectare	No. of Fertilizer Drill per ,000 Hectare	No. of Seed Drill per ,000 Hectare
1972										
Saharanpur	105	250	3	1.0	28	8	6	10	0.19	3
Muzaffarnagar	243	156	2	3	24	20	8	15	0.43	29
Meerut	96	25	4	3	20	26	9	19	0.22	47
Bulandshahr	20	20	0.8	0.7	14	22	3	15	0.13	5
1978										
Saharanpur	31	262	9	8	74	14	12	19	0.48	0.9
Muzaffarnagar	170	210	16	15	47	31	22	30	0.53	67
Meerut	273	156	11	11	41	44	14	34	0.77	58
Bulandshahr	302	26	4	4	23	41	6	32	0.24	11
Ghaziabad	279	54	8	8	42	19	12	27	10	48
1983										
Saharanpur	50	234	16	16	97	25	21	34	8	3
Muzaffarnagar	170	246	90	27	73	50	35	45	11	7
Meerut	294	204	51	19	62	63	27	18	11	8
Bulandshahr	258	40	7	7	34	52	13	60	5	7
Ghaziabad	351	80	32	17	74	43	23	50	11	4
1988										
Saharanpur	47	259	28	24	140	41	32	4	2	2
Muzaffarnagar	171	278	87	38	117	71	50	4	5	12
Meerut	294	193	39	33	103	74	47	4	6	18
Bulandshahr	297	80	3	14	81	82	20	2	3	7
Ghaziabad	260	62	7	23	107	57	31	18	3	13
1993										
Saharanpur	23	210	30	28	162	58	18	4	0.58	0.58
Muzaffarnagar	184	277	102	16	95	79	67	10	6	10
Meerut	265	162	45	8	77	77	46	3	14	14
Bulandshahr	202	80	3	10	85	81	26	8	3	4
Ghaziabad	240	40	13	4	146	56	48	4	1	1

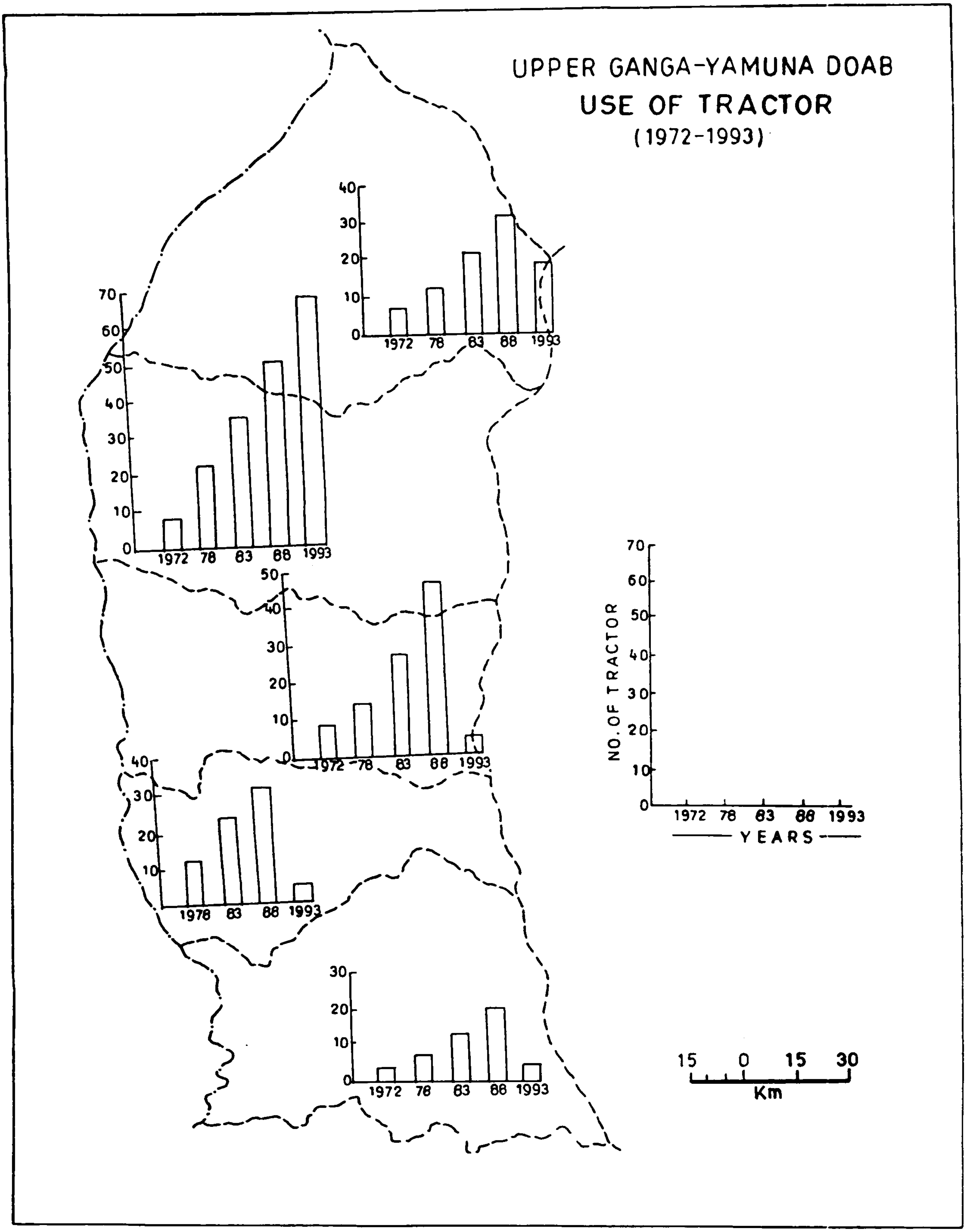

UPPER GANGA-YAMUNA DOAB
USE OF TRACTOR
(1972-1993)
NO. OF TRACTOR
YEARS
1972 78 83 88 1993
15 0 15 30
Km

Fig. 3.1

The Table 3.1 shows the wide variation in the use of tractor in different districts of Upper Ganga-Yamuna Doab. The highest numbers of tractors per thousand hectares are found in Muzaffarnagar district, ranging from 8 to 67 in 1972-1993, while the lowest number of tractor per thousand hectares are found in Ghaziabad and Bulandshahr which shows decreasing in trend. This may be happened either due to rapid urbanization or the agriculture area was brought under different uses. Where as in Muzaffarnagar and Saharanpur districts, the rising trend of tractorisation clearly indicates that the farmers have bigger size of land holding and having high literacy level. Besides, most of the big farmers are economically well off and efforts to make high investment by way of mechanising their agriculture. The lower level of tractorisation in Bulandshahr and Ghaziabad district can be attributed to the preponderance of marginal and small level of holding, high density of agricultural population in general and agricultural labourers in particular. In all, the social and economic deprivation can be supposed to be the root cause for insignificant level of adoption of tractors.

Electric Pump Set

The spatio-temporal analysis of electric pump is shown in Table 3.1 and Figure 3.2. There is a tremendous growth of electric pump sets per thousand hectares in different districts from 1972 to 1993. The highest number is found in Bulandshahr district, the lowest record is found in Saharanpur and Ghaziabad district. These variations are attributed that the maximum area is under canal irrigation.

Diesel Pump Set

It is another important machine used for various agricultural operations from irrigation to threshing and other minor works. The

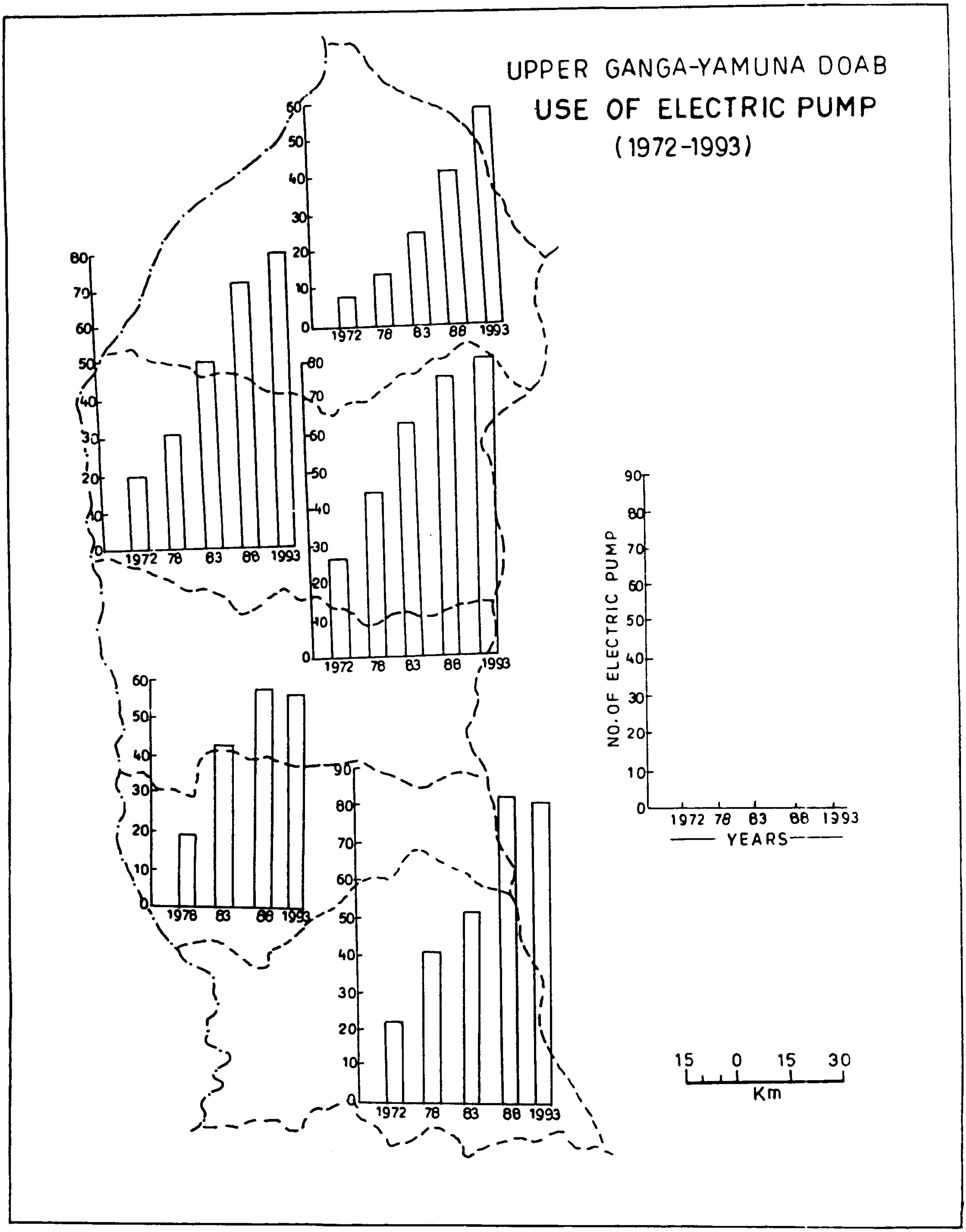

UPPER GANGA-YAMUNA DOAB
USE OF ELECTRIC PUMP
(1972-1993)
NO. OF ELECTRIC PUMP
YEARS
1972 78 83 88 1993
15 0 15 30
Km

Fig. 3.2

Table 3.1 and Figure 3.3, indicates the rising trend of diesel pump sets per thousand hectares in the study area. This may be due to the facts that maximum areas are brought under irrigation through tube wells for multiple cropping and to ensure assured irrigation in case of failure of monsoon.

Iron Plough

Figure 3.4 reveals spatio-temporal development of iron plough in Upper Ganga-Yamuna Doab. The trend of the use of iron plough in Saharanpur district from 1972 to 93 is almost the same, with minor increase in 1978 and 1988. The substantial increase during that period is due to the technological breakthrough in the region. The trend of growth is of iron plough in Muzaffarnagar district is very faster than Saharanpur district. The number of iron plough has increase from 160 to 260 in 1972 and 1993 respectively. But the position is sound in Saharanpur district, where the level of growth since beginning starts from 240 iron plough per thousand hectares. This may be due to the fact that the farmers of Muzaffarnagar responded the diffusion of innovations of modern implements gradually and slowly. While three other districts such as Meerut, Ghaziabad and Bulandshahr were less responsive in the adoption of new technology just after the inception of green revolution but their growth was very slow as compared to the above said districts. Among these three districts the position of Meerut in the adoption of iron plough is better than Bulandshahr and Ghaziabad districts.

Wooden Plough

Figure 3.5 shows the spatio-temporal growth of wooden plough in Upper Ganga-Yamuna Doab. The three districts Meerut, Ghaziabad and Bulandshahr indicate the maximum use of wooden plough and their trend indicate almost a rising trend in the use of

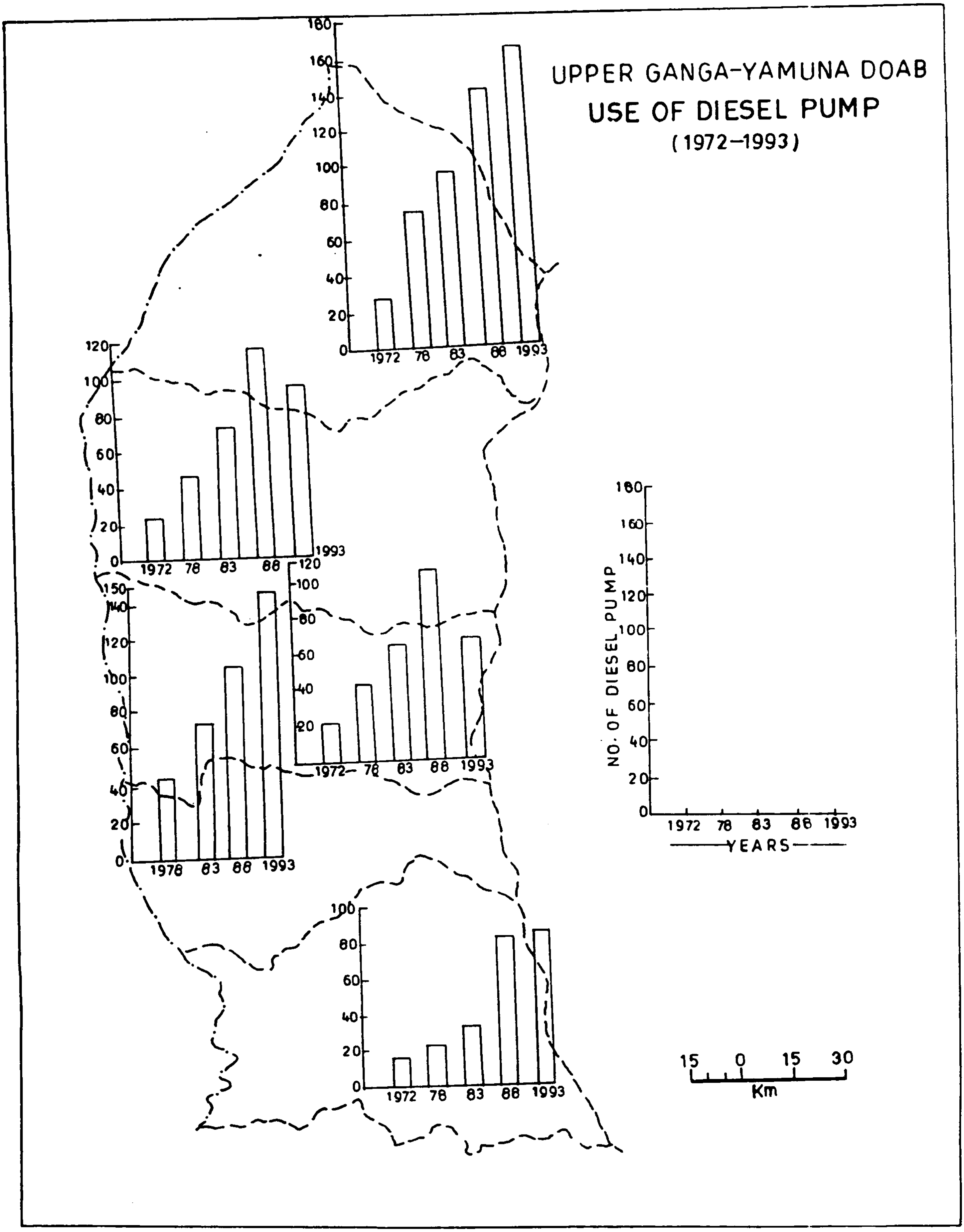

UPPER GANGA-YAMUNA DOAB
USE OF DIESEL PUMP
(1972-1993)
NO. OF DIESEL PUMP
YEARS
1972
78
83
88
1993
15
0
15
30
Km

Fig. 3.3

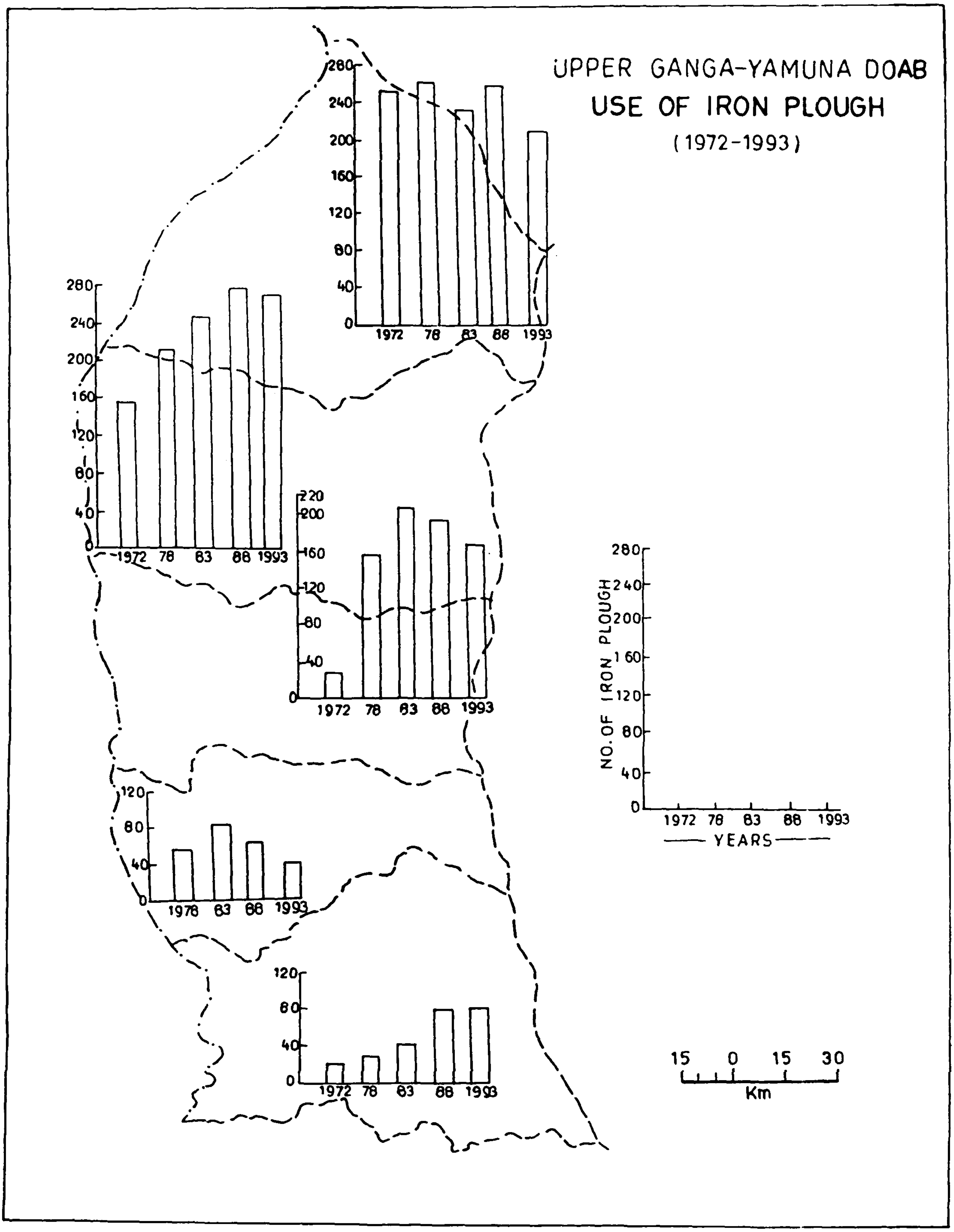

UPPER GANGA-YAMUNA DOAB
USE OF IRON PLOUGH
(1972-1993)
NO. OF IRON PLOUGH
YEARS
1972 78 83 88 1993
15 0 15 30
Km

Fig. 3.4

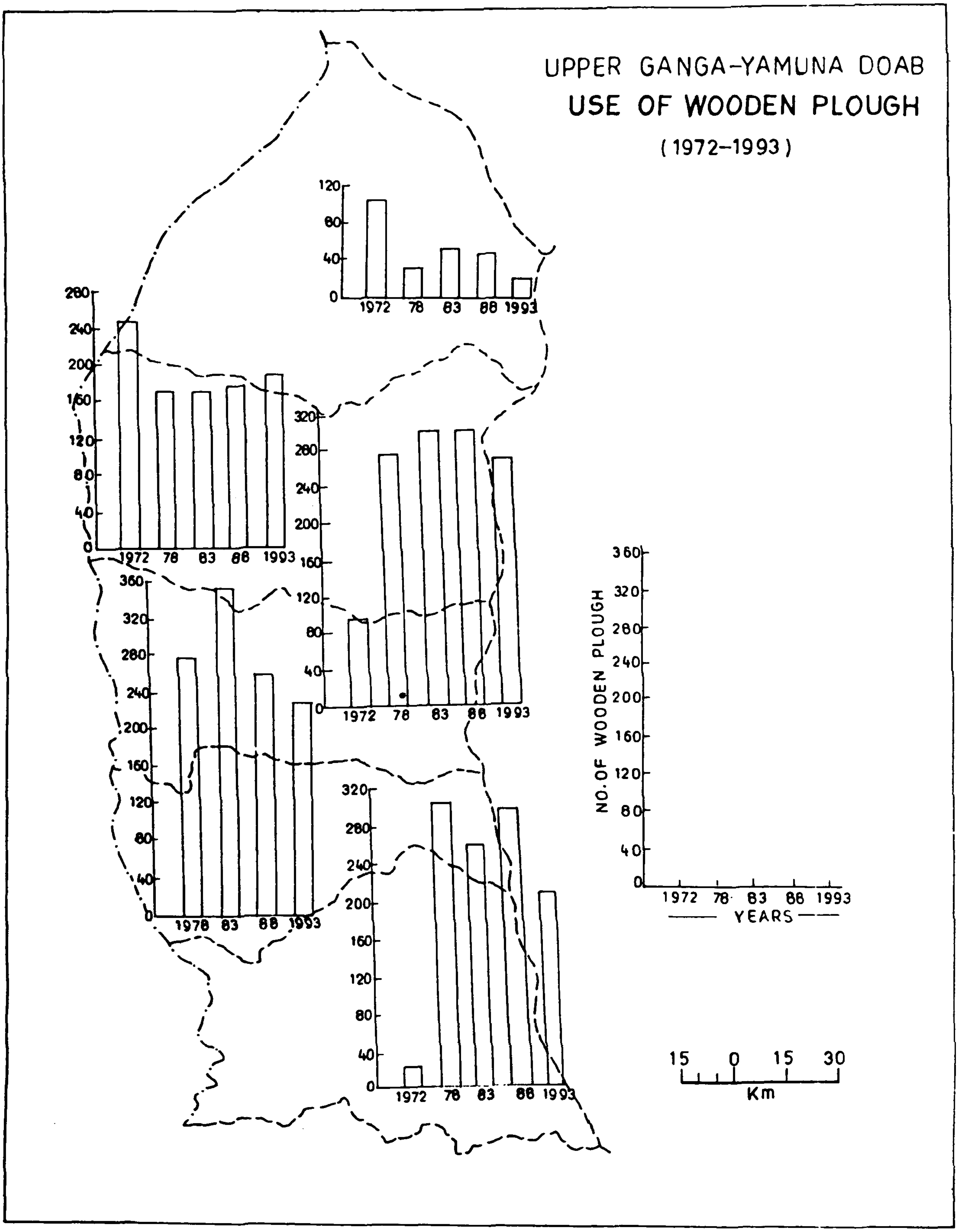

UPPER GANGA-YAMUNA DOAB
USE OF WOODEN PLOUGH
(1972-1993)
NO. OF WOODEN PLOUGH
YEARS
1972 78 83 88 1993
Km
15 0 15 30

Fig. 3.5

traditional implements. Only one district i.e., Saharanpur followed by Muzaffarnagar exhibited the declining trend of use of wooden plough. As far as Muzaffarnagar is concern initially the use of wooden plough was higher but it has declined in subsequent year. But the rate of declining is not much as in Saharanpur district. It is obvious that Shahranpur was the first district followed by Muzaffarnagar of the Upper Ganga-Yamuna Doab, responded the acceptance of new technology against the use of traditional implements.

Other Improved Tools

The tools including hand hoes, threshers, harrows, seeddrills, and dibelers etc. are the developed means for soil preparation, sowing and inter culture. Figure 3.6 the Table 3.1 clearly reveals the rising trend of improved tool in the study area. It indicates the level of mechanisation of agriculture and diffusion of innovations in different district of the region.

Agricultural Labourers

The role of agricultural labourers are immense important, in performing numerous activities at various stages that are from soil preparation to threshing, especially in traditional agricultural economy. On the other hand its expands, is explained regional disparities in rural economic development in general and agricultural growth in particular. As per (1970-1971) district Muzaffarnagar has accounted (27.97 percent) agriculture labourers, where as Saharanpur, Meerut, Bulaundshahr, accounts (26.88 percent), (16.32 percent), and (17.51 percent) respectively. This figure found to rise from 1971 to 1991. These districts attain about 4 to 5 percent increment, except Ghaziabad, which tended to decline by 4% (Table 2.3a).

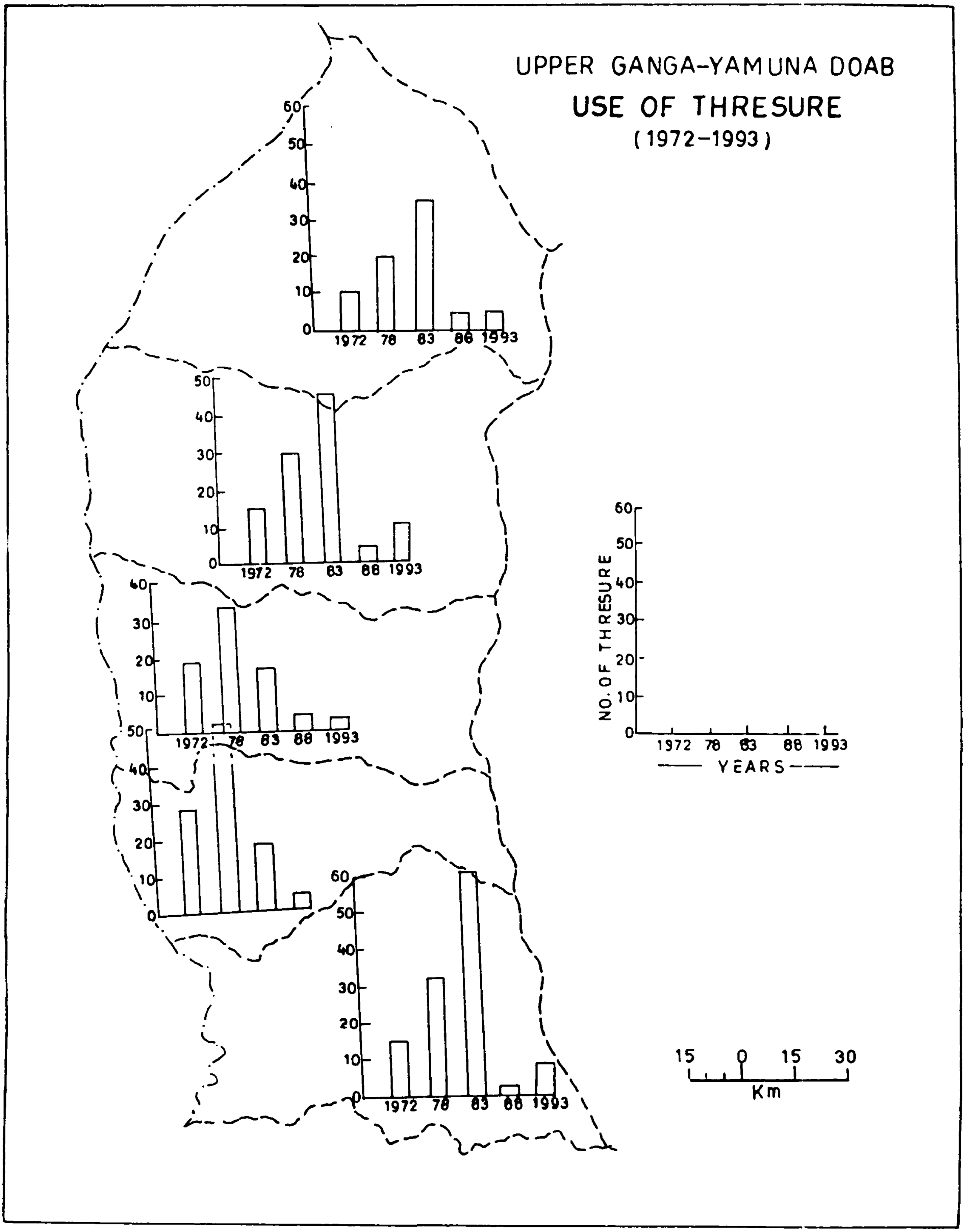

UPPER GANGA-YAMUNA DOAB
USE OF THRESURE
(1972-1993)
NO. OF THRESURE
YEARS
1972 78 83 88 1993
15 0 15 30
Km

Fig. 3.6

Agricultural Credit

The facilities of agricultural credit play vital role in the process of agricultural development. Farming as a business need a large amount of capital. Majority of the farmers therefore, depends on credit. Farmers need agriculture credit for various purposes such as to meet the cultivation expenses, purchase of implements and other materials to acquire new land, to improve land by irrigation, to purchase of land and other personal necessity. Therefore, co-operative banks are regarded as best agencies to provide productive loans to the farmers for purchasing different agricultural inputs. The marketing co-operative society distributes agricultural implements, fertilizer, seeds, and pesticide to farmers. The loan facilities are provided to the farmers by the nationalised bank also, in addition to the co-operative bank. The loan is sanctioned to farmers according to the expenditure incurred in production in various crops. A part from providing loan facilities to the farmer it is necessary that they should get the right price for their crops in return to pay their loan easily. For this purpose regular markets have been open up at different places in the region. Table 3.2 shows district wise number of co-operative banks per lakh of population from 1971 to 1991.

Table 3.2

Districtwise Number of Co-operative Banks per lakhs of Population

Districts	1970-71	1980-81	1990-91
Saharanpur	5.04	9.35	17.86
Muzaffarnagar	6.06	10.29	19.96
Meerut	7.67	12.76	23.80
Bulandshahr	5.04	15.14	30.32
Ghaziabad	-----	8.13	30.63

Source: Based on the data obtained from Directorate of Agricultural, Lucknow, UP.

There was a sufficient growth in the number of co-operative banks per lakh population from 1971 to 1991 in earns an every district of the region. The highest frequency is recorded in Ghaziabad district.

Pattern of Land Ownership

The nature of the ownership of land has an importance in the agrarian economy. The peculiar condition of land ownership in India is that the operational holdings are very small and preponderance of land holdings with size of land less than one hectare. Their number is 30.7 million constitute more than 50 percent of the total operational holding in the country.

The Table 3.3 indicates that there has been wide inequality in the distribution of land. Marginal land holding shares more than 50 percent of the total land holding. Where as large size of holdings share only 1.13 percent of the total numbers but its coverage of the area is about 9.99 percent of the total area in 1971. There is continuous increase in the marginal land holding that is 58.86 percent and percentage its covered area was 16.91 in 1981. Where it was 12.29 percent in 1971, The percentage of large size of holding is 0.56 and its percentage covered area is 5.89 in 1981. In 1991 the share of marginal landholding is 63.53 percent and its percentage covered area about 21.38 percent where as the share of the large size of holding is 0.28 percent and its percentage covered area is 3.44.

Table 3.3 and Figure 3.7 clearly reveal that there is continuous increase in the percentage covered area of marginal land holding. On the other hand the category under small medium and large size of holding tend to decrease. This trend is found in the region as a whole as well as in each district of the region.

Table 3.3
UPPER GANGA-YAMUNA DOAB
SIZE OF LAND HOLDING
(1971-1991)

District	Marginal		Small		Semi-medium		Medium		Large	
	% of No. holding	% of area of holding	% of No. holding	% of area of holding	% of No. holding	% of area of holding	% of No. holding	% of area of holding	% of No. holding	% of area of holding
1971										
Saharanpur	48.05	10.17	19.01	15.18	15.70	26.72	15.99	1.61	12.02	12.02
Muzaffarnagar	52.34	11.20	19.43	15.91	16.70	26.95	10.20	1.33	12.10	12.10
Meerut	54.82	14.71	19.85	19.08	16.64	29.31	7.97	0.72	7.33	7.33
Bulandshahr	48.88	13.08	22.96	19.40	18.74	29.85	8.64	0.88	8.50	8.50
U.G.Y.D. Total	204.09	49.16	81.25	69.57	67.70	112.83	42.80	128.5	4.54	39.95
%age Average	51.02	12.29	20.31	17.39	16.93	28.21	10.70	32.13	1.13	9.99
1981										
Saharanpur	56.68	14.70	19.12	17.80	14.88	27.86	8.53	32.42	0.79	7.22
Muzaffarnagar	59.16	14.58	18.27	17.91	14.03	28.40	7.85	31.72	0.71	7.39
Meerut	58.69	16.82	19.60	20.52	14.67	30.60	6.64	27.68	0.40	4.38
Bulandshahr	56.11	17.16	21.45	20.37	15.27	30.31	6.67	26.95	0.50	5.21
Ghaziabad	63.67	21.29	19.18	22.72	11.90	28.06	4.84	22.66	0.41	5.27
U.G.Y.D. Total	294.31	84.55	97.62	99.32	70.75	145.23	34.53	141.43	2.81	29.47
%age Average	58.86	16.91	19.52	19.86	14.15	29.05	6.91	28.29	0.56	5.89
1991										
Saharanpur	60.26	17.78	18.96	20.59	14.14	30.68	6.22	26.60	0.42	4.35
Muzaffarnagar	65.27	20.52	17.22	23.26	11.99	28.19	5.26	24.65	0.26	3.38
Meerut	63.12	22.38	19.04	23.92	12.36	28.63	4.44	22.05	0.24	3.02
Bulandshahr	60.94	21.06	20.77	25.01	12.99	28.34	5.00	21.93	0.30	3.66
Ghaziabad	68.04	25.17	17.84	26.11	11.07	30.08	2.86	15.85	0.19	2.79
U.G.Y.D. Total	317.63	106.91	93.83	118.89	62.55	145.92	23.78	111.08	1.41	17.20
%age Average	63.53	21.38	18.77	23.78	12.51	29.18	4.76	22.22	0.28	3.44

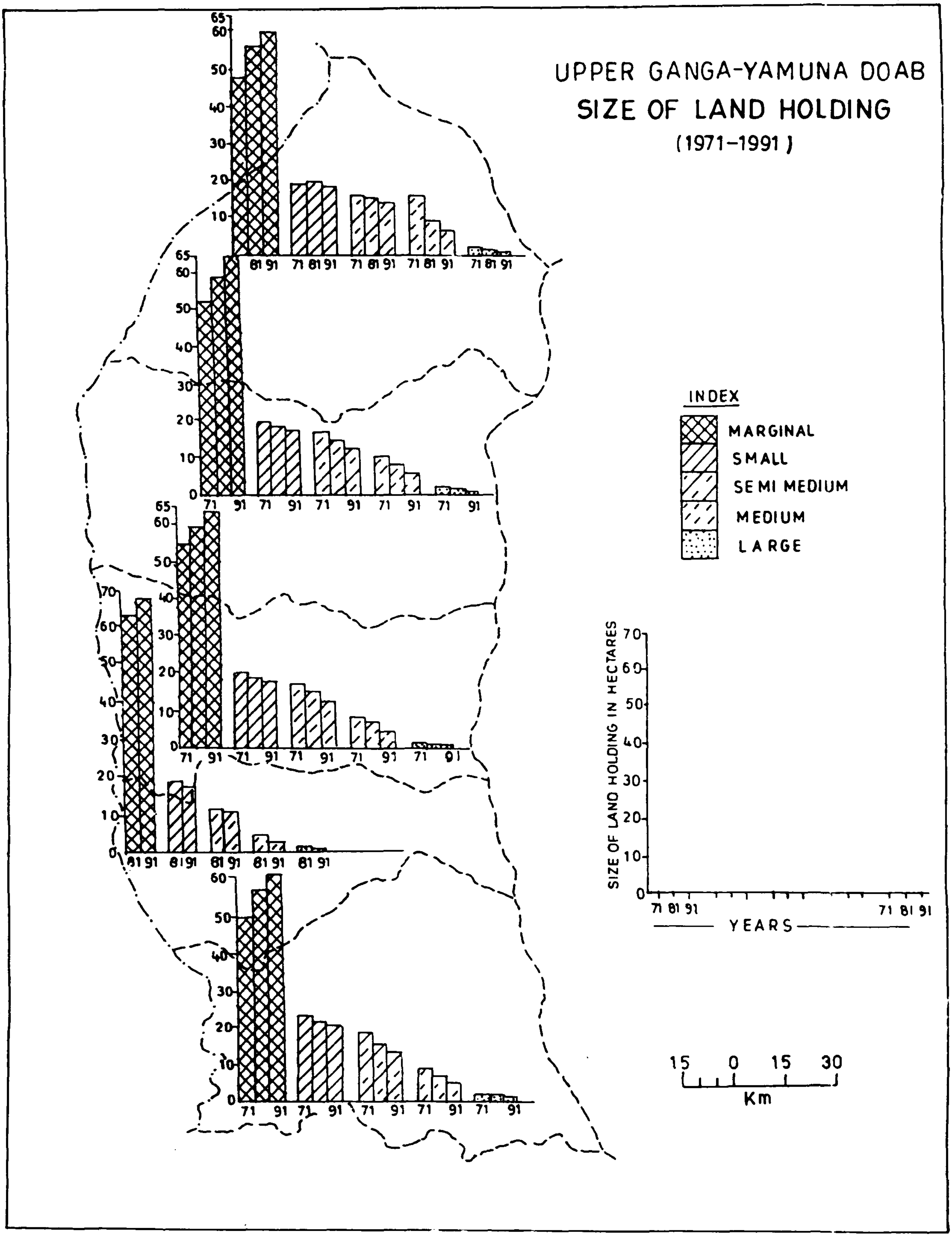

UPPER GANGA-YAMUNA DOAB
SIZE OF LAND HOLDING
(1971-1991)
INDEX
MARGINAL
SMALL
SEMI MEDIUM
MEDIUM
LARGE
SIZE OF LAND HOLDING IN HECTARES
0
10
20
30
40
50
60
70
71 81 91
71 81 91
YEARS
15 0 15 30
Km

Fig. 3.7

The study area i.e., Upper Ganga-Yamuna Doab has greater land inequalities having marginal land holdings of an average size of 0.33 hectare, small size of holding of 1.52 hectare, medium and large size of holding 4.51 and 16.12 hectare respectively.

Pattern of Irrigation

The spread of new technology, particularly the high yielding variety (HYV) and the use of fertilizers is conditioned by the availability of water. It may not be appropriate to leave agriculture to the vagaries of monsoon. In monsoon lands where the rainfall and its distribution show wide fluctuations, irrigation facilities are must for achieving assured and high level of agricultural production.

In areas where rainfall is plentiful and well distributed over the year, there is no problem of water. But some area experienced very erratic and uncertain rainfall. Therefore, in this area artificial irrigation is absolutely essential. The creation of irrigation facilities not only induces farmers to change their cropping pattern by substituting high value crops in place of low value crops and replacing traditional varieties by new ones, it also helps for in intensive use of inputs to maximise the agricultural productivity.

The study area has vast reservoir of surface and ground water, fertile soil and good climatic conditions. The region is drained by the perennial rivers of the Ganga system which have their source in the Himalayas. The vast leveled plain and gentle slope offers conducive environment for the construction and development of canal, for irrigation. Beside its water contributes to maintain the sub-soil water table. This region receives 60 to 70 cm rainfall and 90 percent of the total rainfall occurs during the rainy season. Even during the rainy season, there are long dry spells in between irrigation, therefore, it is necessary for the growing of the kharif crops and rabi crops during the winter and it is desirable even in the rainy season to counter the effect the short dry spells.

Source Wise Irrigation Development Trends

The irrigation sources of the study area fall into four traditional types, canals, tube wells, wells and other sources. The first two sources account 86 and 97 percent of net irrigated area in 1970-71 and 1992-93. Tube well alone accounts 43.60 percent and 70.87 in 1970-71 and 1992-93 respectively. The Tables 3.4a, b and Figure 3.8 show that rapid increase of irrigated area under tube well irrigation, canal irrigation comes next which accounts 42 and 26.98 percent in 1970-71 and 1992-93 respectively, making a declining trend. Other sources including wells, tanks which are important in only small localities and together irrigate only about 14.31 percent in 1970-71 and 2.15 percent in 1992-93, which indicates the rapid decline of irrigation under other sources in the study area.

Tube Well Irrigation

Tube well irrigation represents a modern, scientific and efficient method of exploiting ground water and has greatly contributed to the success of the new agricultural technology, particularly in the northern part of Upper Ganga-Yamuna Doab. Tube well now forms the most important irrigation source, which accounts more than 70.87 percent of net irrigated area. Tube well technology is found ideal in Upper Ganga-Yamuna Doab due to huge amount of ground water found here in a series of sandy acquifers, separated by clay loams, which yields a sustained supply of sweat water, specially when a dug well is strengthened with masonry work. Under ground water reservoirs are replenished annually through infiltration of rains (20-25 percent), seepage from canals and rivers and percolation of irrigation water from fields. The importance of tube well irrigation was fully realised by the late

Table 3.4a
%AGE CHANGE IN IRRIGATED AREA IN UPPER GANGA-YAMUNA DOAB

Sources	1970-71	1980-81	%age change	1980-81	1992-93	%age change	1970-71	1992-93	%age change
Canal	42.00	32.99	-9.01	32.99	26.98	-6.01	42.00	26.98	-15.02
Tube Well	43.60	63.75	20.15	63.75	70.87	7.12	43.60	70.87	27.27
Wells	13.65	2.12	-11.53	2.12	1.27	-0.85	13.65	1.27	-12.38
Other Sources	0.66	1.13	0.47	1.13	0.88	-0.25	0.66	0.85	-0.22

Table 3.4 b
SPATIAL VARIATIONS OF IRRIGATED AREA BY DIFFERENT SOURCES
1970-71 to 1992-93

Districts	Canals	Tube Wells	Wells	Other Sources
Saharanpur	-11.00	21.37	-10.31	-0.17
Muzaffarnagar	-17.36	25.58	-7.90	-0.33
Meerut	-17.08	30.96	-13.41	-0.47
Bulandshahr	-12.48	30.87	-19.99	2.10
Ghaziabad (1977-78 to 93)	-12.30	18.62	-5.91	-0.42

Note: * %age change of irrigation of Ghaziabad starts from 1977-78.

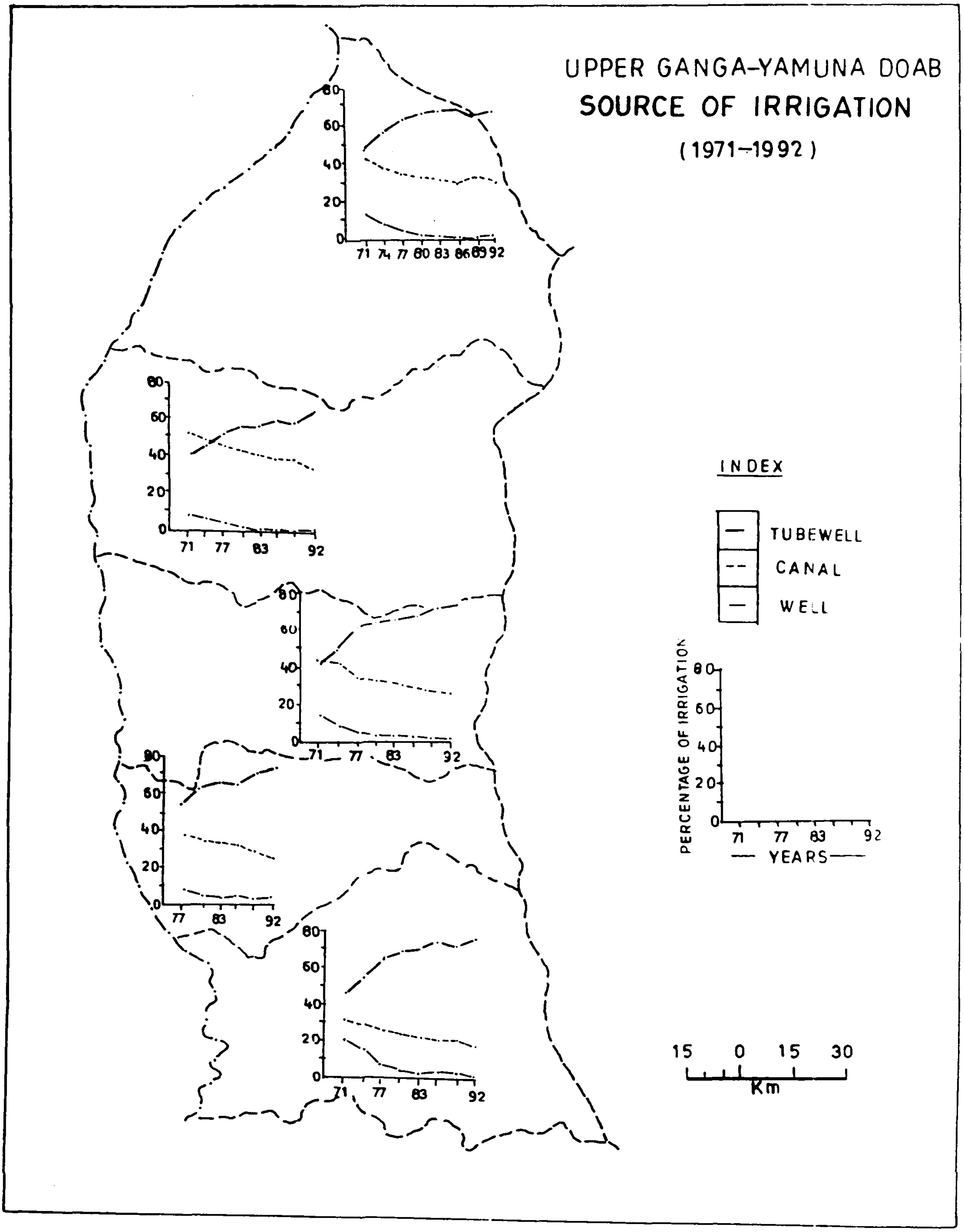

UPPER GANGA-YAMUNA DOAB
SOURCE OF IRRIGATION
(1971-1992)
INDEX
TUBEWELL
CANAL
WELL
PERCENTAGE OF IRRIGATION
YEARS
15 0 15 30
Km

Fig. 3.8

fifties, when private tube wells were induced as common sight in the northwestern districts. The construction of private tube well using electricity or diesel is found relatively cheaper than a public tube well due to its shallow depth and flexibility in terms of capacity and equipment. It works more efficiently as far as time is concerned.

Tube well irrigated area went up from 14.11 lakh hectares to 49.38 lakh hectares from 1970-71 to 1992-93, which accounts more than 43 percent of net irrigated area in 1970-71. It rose to 70.87 percent of the net irrigated area by 1992-93. The two specific programs, which provided a tremendous boost to the growth of tube well irrigation in the region during the late sixties, were: (i) rural electrification, and (ii) provision of liberal capital finance through institutional sources on a large scale.

The farm level data of the study area exhibits cropping intensity were much higher under tube well and canal irrigated area. It is well known fact that farms using tube well and canal irrigation give the highest returns provided several other important conditions are also met with. The significance of the tube well irrigation, in the study area is due to availing better physico-cultural conditions i.e., desirable depth of ground water table and significance of rabi crops than that of other part of Utter Pradesh.

Canal Irrigation

Canal irrigation has attained second place in terms of net irrigated area among different source of irrigation. The area under canal irrigation has successively declined i.e., 42 to 26.98 percent in 1970-71 and 1992-93 respectively. The decline of its aerial extent is not due its misuse and inefficiency of supply of assured irrigation. Farmers felt very easy to use canal water for agricultural practices. It has all the merits over the other sources of irrigation upto seventies. But after the advent of green revolution, the new package technology felt dire need of assured and adequate irrigation in time. This can be made through tube well irrigation alone. At this juncture canal irrigation become failure and subsequently percentage of irrigation under canals started decline and reached to 26.68 percent in 1992-93 from 42 percent in 1970-71.

Other Sources

Only a small-scale area, i.e., about 14 percent of the net irrigated area is currently under wells, tanks, and other sources, mostly lifts on diverted streams in all of which there has been a decline in the recent years. The percentage of irrigated area under wells has rapidly declined from about 14 percent to about 5 percent in 1971 to 1993 respectively. All are very crude, manually operated laborious devices, but all are quite useful small farmers who cannot afford other more expensive methods.

Consumption of Fertilizer

The key to growth in agricultural productivity during a short period lies in intensive use of chemical fertilizer and provided all the factors are constant. In the new strategy, fertilizer has been assigned the role of kingpin because when soil fertility is low, better performance of crop productivity failed to achieve. The continuous deteriorating soil fertility on account of regular cultivation can also be replenished to a great extent by re-supplying nitrogen in the soil through the use of fertilizers, and subsequently enhance the agricultural productivity per unit area. Fertilizers can thus play a significant role in providing a major break through in agricultural production.

Recent studies have shown that great potentialities for a sustained increase in crop production can be attained through greater and more efficient use of fertilizers and manures. FAO's study have shown that the use of fertilizers is more instrumental of agricultural development, because wherever efforts are made to increase agricultural efficiency and productivity to meet the demand of rising population, more fertilizers and manures have been invariably used) Perhaps, even more important, on many soils they make possible good yields of valuable crops that would not grow at all without them, or would grow more poorly. It has also been experienced that even during abnormal rainfall years fertilized crops give higher yields, than unfertilized crops. The reason is that fertilized crops get a good initial start and better development of both root and shoot, which enable them to endure drought to a greater extent than fertilized crops. The researches reveal that continuous use of chemical fertilizers reduces the humus content of the soil. In the absence of the humus, the physical structure of soil under goes vast changes, and the texture of fertile soil is lost, and ultimately soil may lose its water retaining and absorbing capacity. Substitution by organic manures, therefore, is necessary which may replace the desirable physical and biological properties to the soil.

Table 3.5 shows the spatio-temporal consumption of fertilizers kg per hectare district wise in Upper Ganga-Yamuna Doab from 1971 to 1995. Muzaffarnagar, Ghaziabad, Bulandshahr and Meerut highest follow the trend of consumption of fertilizer in Saharanpur district. The consumption of fertilizer in Saharanpur district has increased five times from 1970-71 to 1994-95. In 1971 the consumption of fertilizer kg per hectare was very meagre ie., only 27.64 kg per hectare. It rose to 83.82 kg per hectare in 1983, which is three times more than that of preceding year. The tremendous increase in the use of fertilizer after 1982-83 is due to the impact visible result of 'Green Revolution' and subsequently its trend of consumption increases steadily, and in 1994-95 it accounted 137.7 kg per hectare. The similar trend is found in

Table 3.5
DISTRICS WISE CONSUMPTION OF FERTILIZERS (Kg/Hect.)
1970-95

Year	Saharanpur	Muzaffarnagar	Meerut	Bulandshahr	Ghaziabad
1970-71	27.64	38.99	39.03	26.44	
1971-72	28.89	47.95	44.86	27.73	
1972-73	37.84	56.94	52.71	31.30	
1973-74	41.11	53.08	40.35	23.00	
1974-75	28.00	44.13	39.27	30.93	
1975-76	36.43	46.13	50.41	35.57	
1976-77	50.07	66.76	70.41	49.02	
1977-78	62.20	69.83	112.19	58.53	43.78
1978-79	64.55	71.12	87.98	69.83	78.22
1979-80	59.42	66.28	87.23	65.01	67.69
1980-81	69.00	75.44	100.57	80.03	73.36
1981-82	75.00	81.24	106.81	81.78	86.12
1982-83	78.21	91.37	104.18	77.35	100.98
1983-84	83.82	95.69	110.84	88.11	106.95
1984-85	89.91	97.67	106.52	76.84	111.34
1985-86	109.53	113.01	116.74	94.95	113.40
1986-87	102.78	104.23	105.43	78.04	115.81
1987-88	91.42	99.19	96.02	62.21	139.76
1988-89	118.08	118.06	109.19	89.81	136.11
1989-90	91.68	122.78	116.83	79.53	108.12
1990-91	128.82	132.75	119.05	90.09	111.74
1991-92	127.85	134.60	124.13	93.20	121.80
1992-93	109.08	147.28	113.53	93.88	139.27
1993-94	121.18	161.87	136.96	88.71	154.21
1994-95	137.70	163.37	142.03	96.33	175.46

Muzaffernagar district, which lies very close to Saharanpur district. The trend of consumption from 1970-71 to 1994-95 is more than four times. The district of Meerut and Bulandshahr shows almost the same trends of consumption. Both the districts exhibit 3.64 time increases consumption of fertilizer kg per hectare from the base year that is 1970-71 to 1994-95. Where as the consumption of fertilizer is more phenomenal, in Ghaziabad district, which came into being in 1977-78. The analysis takes its start from inception of the district. The trend of the consumption of fertilizer in the districts goes four times from its base year that is 1977-78 to 1994-95. The phenomenal rise in the trend of consumption of fertilizer in each district of Upper Ganga-Yamuna Doab is due to the fact that hundred percent area are brought under the use of high yielding varieties, and more than 95% area are under irrigation.

TREND OF AGRICULTURAL DEVELOPMENT–AREA, PRODUCTION AND YIELD

The study of agricultural trends of Upper Ganga-Yamuna Doab provides the basis for evaluating the potential resources and for planning to obtain maximum production for meeting ever increasing demand of food. It is also essential for evaluating and improving in overall economic levels. After the advent of new technology in agriculture tremendous efforts have been made in India for increasing total supplies of food grains. Nevertheless, the performance of growth is quite uneven from one crop to another. Considering that Upper Ganga-Yamuna Doab has witnessed a conspicuous upheaval in this agriculture during last two and half decades. The present chapter seeks to analyse the agro-economic trend of Upper Ganga-Yamuna Doab and its districts in relation to area, production and yield from 1970 to 1993. The objective of the study is to examine the overall changes in broad land use categories, to interpret the changes in area, production and yield of crops during the periods, and to determine the impact of irrigation, fertilizer and other technological inputs in the production levels. Area under crops is largely governed by physico-cultural and techno-economic factors. Physical factors specify the range of crops that can be grown in a region. It describes the production possibilities of crops and offers many choices. The economic factors have been determining influence on cropping pattern.

The Upper Ganga-Yamuna Doab comprising of five districts, Saharanpur, Muzaffarnagar, Meerut, Bulandshahr and Ghaziabad, is the seat of green revolution and that is why it has been choosen the study area. The region is agriculturally prosperous, fertile and highly irrigated northwestern part of Uttar Pradesh. It is a flat, monotonous and productive plain. The total area of the study region is 19,00,312 hectares of which, 75.69% is net sown area and 123.58% is gross cropped area. The net irrigated area is 88.53% of the net sown area, of which 70.48% is irrigated by tube wells and 27.77% by canals.

Cultivation of crop has been the main occupation The economic classification of population shows that about 70 percent are non workers and 30 percent are main workers. Among the main workers, 40 percent are cultivators and 22 percent agriculture labourers and rest are employed in household industries and other occupations. Though the bulk of the farmers belong to the marginal categories (< 1 hectare), but the proportion is comparatively lesser than rest of Uttar Pradesh. Farmers having semi medium (2 to 4 hectare), medium (4 to 10 hectare) and large holdings (> 10 hectare) are found. Generally the medium and large size of landholders are predominant in the study area (Table 3.3).

The basic data for the present study have been obtained from the Agricultural Statistics of Uttar Pradesh from 1970 to 1993 for all the districts except Ghaziabad, because it came into being in 1976. And therefore, the analysis of agricultural development of Ghaziabad district has been examined with the available data from 1976 to 1993. The period of the analysis of agricultural development starts just after the lapse of five years of green revolution, though its impact has been realised after 1966. For the sake of convenience and the availability of desirable data of those crops which realised its impacts.

Almost all the main crops have been included namely rice, maize, bajra, jwar, wheat, barley, potato, sugarcane, arhar and mustard. The present analysis examines the percentage change in area, production and yield of all the crops. In order to measure the variability of patterns, trend line has been fitted with the regression line of the form:

$$Yc = a + bx$$

The regression line makes it possible to predict the exact change in the production level at various points of time. Similarly, three years moving average has been plotted in the time series graph to show the clear trend of change. The coefficient of correlation is worked out and tested for the level of significance by 't test'.

Land Use Pattern

Land use patterns are extremely complex pattern, falling into different categories. This complex land use pattern is the result of centuries of human settlement and development representing the interaction of physical, historical, social and economic factors. In densely populated region, land has become a major commodity presenting a complex problem of supply and demand. The objective of incorporation of land use pattern in this chapter is of two fold.

a. The geographical area classified into various types which may be referred to as broad land use; and b. the various facets of cultivated area which may be referred to as cropping pattern.

Since, the region as a whole is one of the densely populated part of the country, the farmers hold an important position in explaining the rational use of various categories of land utilization of each districts of Upper Ganga-Yamuna Doab, as well as the region as a whole. The land use is a important aspect of geographical studies and the progress of an area can be measured to a certain degree by the way in which its land is used and maintained. The percentage of area under forest is very low, it means intensive use of land for cultivation. The area covered by forest is merely 5.36 percent in 1992-93, while it was 5.61 percent of the total reported area in 1970-71 of the region. The barren and uncultivable area has also declined from 3.03 percent in 1970-71 to 1.96 percent in 1992-93, while the land put under non agricultural uses including area under roads, railways and settlement has increased significantly from 9.44 percent to 11.55 percent in 1970-71 to 1992-93 respectively. The cultivable waste land has also declined from 3.46 percent in 1970-71 to 1.52 percent in 1992-93.

Permanent pasture and other grazing land also indicate the declining trend in the region i.e., 0.21 percent in 1970-71 to 0.16 in 1992-93. The land under miscellaneous uses has also declined from one percent in 1970-71 to 0.34 percent in 1992-93. The net sown area of the region has increased from 73.91 in 1970-71 to 75.69 percent in 1992-93, indicating 1.78 percent increment. The gross cropped area and area sown more than once has also increased i.e., 16.33 percent and 14.56 percent in 1992-93 and 1970-71, respectively. Similarly the land use pattern of each district of Upper Ganga-Yamuna Doab has also been analysed which indicates almost the same trend of that of region with the few exceptions. The forest covered area in Saharanpur district has increased 2.84 percent in 1992-93. The increasing trend has also been realised in Meerut. Bulandshahr and Ghaziabad districts with varying degree except Muzaffarnagar. The land put to non agricultural uses has declined to 1.04 percent in Saharanpur district whereas, it indicates the increasing trend of varying percentage in

Muzaffarnagar, Meerut, Bulandshahr and Ghaziabad. The net sown area has been declined 4.43 percent in Ghaziabad but all the district like Saharanpur, Muzaffarnagar, Meerut and Bulandshahr realised more than 2 percent increment from 1970-71 to 1992-93 (Table 3.6).

Cropping Pattern

The study of cropping pattern involves the description of area under various crops and change there in overtime gives a clue to understand the option preferred by farmers. (The cropping pattern almost differed from district to district in the region, in space and time due to interplay of physico-cultural and technological factors.) (Table 3.7 presents area under some important crops as percentage to the gross cropped area, it reveals that wheat predominates over all other crops and the magnitude of area of wheat has declined.) In 1970-71 it covered 33.77 percent, while in 1992-93 it registered about 31.44 percent. It is significant to note that area under sugarcane is higher than paddy and it registered the growth rate of 6.02 percent. In 1970-71 it covered an area of about 18.41 percent and in 1992-93 it rose to 24.43 percent. The area under potato has also increased to about 0.57 percent. The area under paddy has declined by 1.35 percent. The area under maize grew upto 11.4 percent in 1970-71 and it declined to 7.67 percent in 1992-93. These results aptly suggest that cropping pattern is changing in region and shift from cereals to cash crops such as sugarcane and potato has been felt. These variations have their genesis in the human choice to grow cash crops for monetary gain and facilities easily available to the farmer.) The districtwise analysis of the cropping patterns indicates that the area in the different crop also exhibits almost the same pattern with few exceptions. (The

TABLE 3.6

UPPER GANGA-YAMUNA DOAB

LAND UTILISATION STATISTICS

(1970-71 TO 1992-93)

S. NO.	LAND UTILISATION/ DISTRICT	SAHARANPUR			MUZAFFAR NAGAR			MEERUT			BULANDSHAHR			GHAZIABAD			UPPER GANGA-YAMUNA DOAB		
		1970-71	1992-93	%age Change	1970-71	1992-93	%age Changee	1970-71	1992-93	%age Change	1970-71	1992-93	%age Change	1970-71	1992-93	%age Change	1970-71	1992-93	%age Change
1.	Reporting Area for land Utilization	551279	394941	-	434282	417553	-	597737	391714	-	491081	437139	-	257739	258965	-	2074359	1900312	-
2.	Forest	77823	66988	-	19199	16204	-	11080	7993	-	1417	8192	-	N.A.	2556	-	116519	101933	-
		(14.12)	(16.96)	+2.84	(4.42)	(3.88)	-0.54	(1.85)	(2.04)	+0.19	(1.71)	(1.87)	+0.16	-	(0.99)	+0.99	(5.61)	(5.36)	-0.25
3.	Barren & Un-cultivable land	7027	3774		3590	7272	-	19255	5478	-	23103	12800	-	11229	8274	-	62975	37398	-
		(1.27)	(0.96)	-0.31	(3.12)	(1.74)	-1.38	(3.22)	(1.40)	-7.82	(4.70)	(2.88)	-1.82	(4.35)	(3.19)	-1.16	(3.03)	(1.96)	-1.07
4.	Land put to non-agricultural uses	62319	40528	-	40282	52928	-	57477	46926	-	35729	39953	-	27293	39017	-	195804	219412	-
		(11.30)	(10.26)	-1.04	(9.27)	(12.69)	+3.42	(9.61)	(11.98)	+2.37	(7.27)	(9.14)	+1.87	(10.59)	(15.06)	+4.47	(9.44)	(11.55)	+2.11
5.	Cultivable wastages	13647	1403	-	13888	3852	-	19935	5423	-	21376	10824	-	11071	7426	-	71846	28928	-
		(2.48)	(0.36)	-2.12	(3.19)	(0.92)	-2.27	(3.33)	(1.38)	-1.95	(4.35)	(2.47)	-1.88	(4.29)	(2.86)	-1.43	(3.46)	(1.52)	-1.94
6.	Permanent Postures & other grazing land	562	298	-	1099	540	-	602	342	-	2084	1461	-	454	489	-	4437	3130	-
		(0.11)	(0.07)	-0.04	(0.25)	(0.12)	-0.13	(0.10)	(0.09)	-0.01	(0.42)	(0.33)	-0.09	(0.17)	(0.19)	+0.02	(0.21)	(0.16)	-02 0
7.	Land under miscel-eneous tree,grooves not included	4317	1008	-	5108	2236	-	4149	528	-	7182	1494	-	1904	1275	-	20756	6539	-
		(0.76)	(0.25)	-0.51	(4.17)	(0.54)	0.63	(0.69)	(0.13)	-0.56	(1.46)	(0.34)	-1.12	(0.74)	(0.49)	-0.25	(1.00)	(0.34)	-0.66
8.	Current fallows	12950	3969	-	10973	6267	-	1444	6199	-	10771	8066	-	9372	7855	-	36038	32356	-
		(2.34)	(1.00)	-1.34	(2.53)	(1.50)	-1.03	(0.24)	(1.58)	+1.34	(2.19)	(1.84)	-0.35	(3.63)	(3.03)	-0.6	(1.74)	(1.70)	-0.04
9.	Other fallows	2736	2446	-	4658	4347	-	8015	7093	-	7124	7640	-	4521	10742	-	22533	32268	-
		(0.49)	(0.61)	+0.21	(1.07)	(1.04)	-0.03	(1.34)	(1.71)	+0.47	(1.45)	(1.75)	0.30	(1.75)	(4.15)	+2.4	(54.08)	(1.69)	+0.61
10.	Net sown area	369808	274527	-	325748	223847	-	462780	311732	-	375274	746905	-	191894	181337	-	1533347	1438344	-
		(67.08)	(69.51)	+2.43	(74.95)	(77.56)	+2.61	(77.42)	(79.58)	+2.16	(76.42)	(79.36)	+2.94	(74.45)	(70.02)	-4.43	(73.91)	(75.69)	+1.78
11.	Area sown more than once	158517	172779	-	137128	185432	-	223259	192861	-	172440	240220	-	105756	119030	-	691344	910122	-
		(28.75)	(43.75)	+15.00	(31.57)	(44.40)	+12.83	(37.35)	(49.18)	+11.83	(35.11)	(54.95)	+19.84	(41.03)	(45.96)	+4.93	(33.33)	(47.89)	+14.56
12.	Gross cropped area	528325	447306	-	462613	509279	-	686039	504393	-	547714	587125	-	297650	300363	-	2224691	2348466	-
		(95.84)	(113.26)	+17.42	(106.52)	(121.98)	+15.44	(114.77)	(128.76)	+13.99	(111.54)	(134.21)	+22.77	(115.48)	(115.99)	+0.51	(107.25)	(123.58)	+16.33
13.	Cropping intensity	142.86%	162.93%	+20.07	142.13%	157.25%	+15.12	148.24%	161.80%	+13.56	145.95%	169.24%	+23.29	155.11%	165.64%	+10.53	144.8%	163.4%	+18.6
14.	Net irrigated area	186346	203773	-	250730	311116	-	380024	289477	-	289933	295970	-	161814	173064	-	1107033	1273400	-
		(50.39)	(74.23)	+23.84	(77.03)	(96.06)	+19.03	(82.11)	(92.86)	+10.75	(77.26)	(85.32)	+8.06	(84.32)	(95.44)	+11.12	(72.20)	(88.53)	+16.33
15.	Area irrigated more than once	58593	153490	-	91288	157417	-	167163	208813	-	90811	276039	-	73278	116222	-	407855	911981	-
		(15.84)	(55.91)	+40.07	(28.04)	(48.61)	+20.57	(36.12)	(66.98)	+30.86	(24.20)	(79.57)	+55.37	(38.18)	(64.09)	+25.91	(26.60)	(63.40)	+36.8
16.	Total irrigated area	244939	357263	-	342018	668533	-	547187	498290	-	380744	572009	-	235090	289286	-	1514888	2185381	-
		(66.23)	(130.14)	+63.91	(105.08)	(144.67)	+39.59	(118.24)	(159.84)	+41.6	(101.46)	(164.89)	+63.43	(122.51)	(159.53)	+37.02	(98.79)	(151.94)	+53.15
17.	Irrigated by different sources																		
	(i) Canals	83105	66839	-	132616	106772	-	166427	79017	-	90985	56595	-	82200	44456	-	473133	353679	-
		(44.60)	(32.80)	-11.8	(52.89)	(34.32)	-18.57	(43.79)	(27.30)	-16.49	(31.38)	(19.12)	-12.26	(38.44)	(25.68)	-12.76	(42.74)	(27.77)	-14.97
	(ii) Tube-wells	78944	135648	-	94107	203151	-	152130	208266	-	127329	226294	-	78705	124320	-	452510	897579	-
		(42.36)	(66.56)	+24.2	(37.53)	(62.30)	+24.77	(40.03)	(71.91)	+31.88	(43.92)	(76.46)	+32.54	(46.64)	(71.83)	+25.19	(40.87)	(70.48)	+29.61
	(iii) Others	24297	1266	-	24007	1193		61467	2294		71619	13081		20909	4288		181390	22142	
		(13.03)	(0.63)	-12.4	(9.57)	(0.34)	-9.23	(16.17)	(0.79)	-15.38	(24.70)	(4.42)	20.28	(12.92)	(2.48)	-10.44	(16.38)	(1.74)	-14.64

Note : (i) Figures in brackets for item no 2 to 12 are percentages to the reporting area of the district or the region

(ii) Figures in brackets for item no 14, 15 and 16 are percentages to the net sown area

(iii) Figures in brackets for item no 17 is percentage to net irrigated area

Source Estimated from data taken from Uttar Pradesh Statistical Bulletin, Directorate of Economics and Statistics, Lucknow (1970-71 and 1992-93)

TABLE 3.7

UPPER GANGA-YAMUNA DOAB

%AGE SHARE OF AREA UNDER SELECTED CROPS (1970-71 TO 1992-93)

CROPS/ DISTRICT	SAHARANPUR			MUZAFFAR NAGAR			MEERUT			BULANDSHAHAR			GHAZIABAD			UPPER GANGA-YAMUNA DOAB		
	1970-71	1992-93	%age Change	1970-71	1992-93	%age Change	1970-71	1992-93	%age Change	1970-71	1992-93	%age Change	1970-71	1992-93	%age Change	1970-71	1992-93	%age Change
RICE	16.62	16.11	-0.51	8.6i1	7.69	-0.92	3.97	2.93	-1.04	1.76	1.47	-0.29	2.73	3.74	+1.01	7.74	6.39	-1.35
JAWAR	0.04	0.03	+0.19	0.11	-	-0.11	0.37	0.03	-0.34	2.19	0.68	-1.51	0.74	0.54	-0.20	0.67	0.37	-0.30
BAJURA	2.55	0.06	-2.49	0.92	0.04	-0.88	2.84	0.31	-2.53	6.92	2.47	-4.45	5.77	2.64	-3.13	3.30	1.10	-2.20
MAIZE	7.59	2.81	-4.78	6.00	1.04	-4.96	11.43	3.33	-8.10	20.58	22.31	+1.73	15.01	8.89	-6.12	11.40	7.67	-3.73
WHEAT	24.25	30.53	-1.70	25.12	32.16	-4.85	26.23	31.65	-3.06	22.36	34.76	-1.27	34.76	32.98	-1.78	24.77	31.44	-2.33
BARLEY	0.41	0.05	-0.36	0.10	0.13	-0.03	0.71	0.15	-0.56	4.93	3.74	-1.19	1.72	1.04	-0.68	1.53	1.02	-0.51
GRAM	4.72	0.08	-4.64	2.93	0.16	-2.77	3.45	0.32	-3.13	4.25	1.08	-3.17	2.00	0.21	-1.79	3.83	0.37	-3.46
ARHAR	0.02	0.01	-0.01	0.01	0.05	+0.04	0.14	0.33	+0.19	0.54	1.89	+1.35	0.13	0.83	+0.70	0.18	0.62	+0.44
MUSTARD	0.13	0.08	-0.05	0.07	-	-0.70	0.05	-	-0.5	0.30	0.05	-0.25	0.03	0.02	-0.01	0.14	0.05	-0.09
SUGARCANE	16.97	24.58	+7.61	26.87	38.48	+11.61	20.95	33.59	+12.64	8.85	7.67	-1.18	14.65	17.85	+3.20	18.41	24.43	+6.02
POTATO	0.14	0.03	+0.09	0.23	0.64	+0.41	0.84	1.58	+0.74	0.74	0.93	+0.19	1.00	1.92	+0.92	0.49	1.06	+0.57

Note : Figures are the percentage to the gross cropped area of the district or region.

Source: Estimated from data taken from Uttar Pradesh Statistical Bulletin, Directorate of Economics and Statistics, Lucknow(1970-71 and 192-93) percentage of area under rice cultivation in Ghaziabad district has registered increasing trend of about 1.01 percent from 1970-71 to 1992-93. But all other districts show declining trend of area under rice cultivation. The area under wheat in all the districts occupied highest percentage ranging from 36 to 32 percent. But it registered declining trend in all the districts with varying percentages. However, Bulandshahr district has recorded highest percentage of area under wheat in 1992-93 i.e., 35.06 percent whereas Muzaffarnagar recorded 28.52 percent as the lowest percentage of area under wheat. however it recorded the highest percentage of area under sugarcane i.e., 38.48 percent but the high magnitude of growth of area under sugarcane has recorded in Meerut i.e., 12.64 percent. This district wise analysis further suggest that farmers are paying their attention towards cash crops i.e., sugarcane and potato.

Intensity of Cropping

The intensity of cropping refers to the number of crops grown in a field during an agricultural year. The rapid growth of population has been exerting pressure on land. Land area being inextensible, intensification of cultivated area is the only alternative measures for increasing production. The intensification depends on many physical, technological and institutional factors like favourable climatic regimes, irrigation facilities, agricultural mechanisation, adoption of chemical fertilizers and high yielding variety of seeds. An aggregate impact of these factors changes the land use efficiency, which means the degree of extents to which the net cultivated area is re-sown. The gross cropped area has percentage of net sown area gives a measure of land use efficiency which, in other words, may be said to be the intensity of cropping) The Table 3.8 presents the intensity of cropping of different district of Upper Ganga-Yamuna Doab from 1970-71 to 1993-94. The trend of intensity of cropping reveals that the area is continuously being intensified by sowing number of crops in a field during agricultural year.

(The intensity of cropping varies from district to district in the study area.) (The highest level of cropping intensity are found in Muzaffarnagar and Bulandshahr.) These two districts have acquired percentage growth 15.7 and 11.27 from 1970-71 to 1993-94. Where as in the same decade the percentage growth of intensity of cropping are found below 10.49 in rest of the district of Upper Ganga-Yamuna Doab. The growth of intensity of cropping from 1970-71 to 1993-94 is found highest in Bulandshahr district i.e., 17.12 followed by Saharanpur and Muzaffarnagar i.e., 15.38 and 12.68 percent respectively (Table 3.8).

Table 3.8

Intensity of Cropping and its Percentage Growth (1970-94)

Year	Saharanpur	Muzaffarnagar	Meerut	Bulandshahr	Ghaziabad	U.G.Y.D
1970-71	1.43 10.49	1.42 11.27	1.48 8.78	1.46 15.75	-	1.45 11.72
1980-81	1.58 4.43	1.58 1.27	1.61 2.48	1.18 1.18	1.64 0.61	1.62 1.85
1993-94	1.65 15.38	1.60 12.68	1.65 11.49	17.12 17.12	1.65 -	1.65 13.79

Besides the analysis of the area under different crops and their change from 1970-71 to 1993-94 at district level and in region as a whole. The analysis has also been made the simple growth, the linear growth and trend of the area, production and yield at district level and region of the study area. The data used for the examinations at district level begins from 1970-71 to 1993-94 based on moving average except Ghaziabad district which starts from 1976-77 to 1993-

94 because it was incorporated in the study area in 1976-77. Whereas the analysis of the change of the area, production, yield trend and linear growth begins from 1976-77 to 1993-94 continuously. Table 3.9A shows the area of different crops and simple growth, linear growth and trend at district level on three years moving average from 1970 to 1994. The area of rice has steadily declined from 1976 to 1985 in Saharanpur district and minor change in area has been visualised. Whereas the trend is also shown almost in a increasing trend where in the case of wheat from 1976 to 1985 the area has increased, it is due to the impact of green revolution. Table 3.9B also exhibits the area under selected crops such as barley, potato, sugarcane, arhar and mustard. The area under these crops also explains the same feature but in case of arhar and mustard the area has continuously increased from 1979 to 1985. Where as the area of sugarcane in the same district shows declining trend but in case of potato, shows the increasing trend. Figures 3.9A, 3.9B and 3.9C show the percentage change of area, linear growth and trend respectively in Saharanpur district.

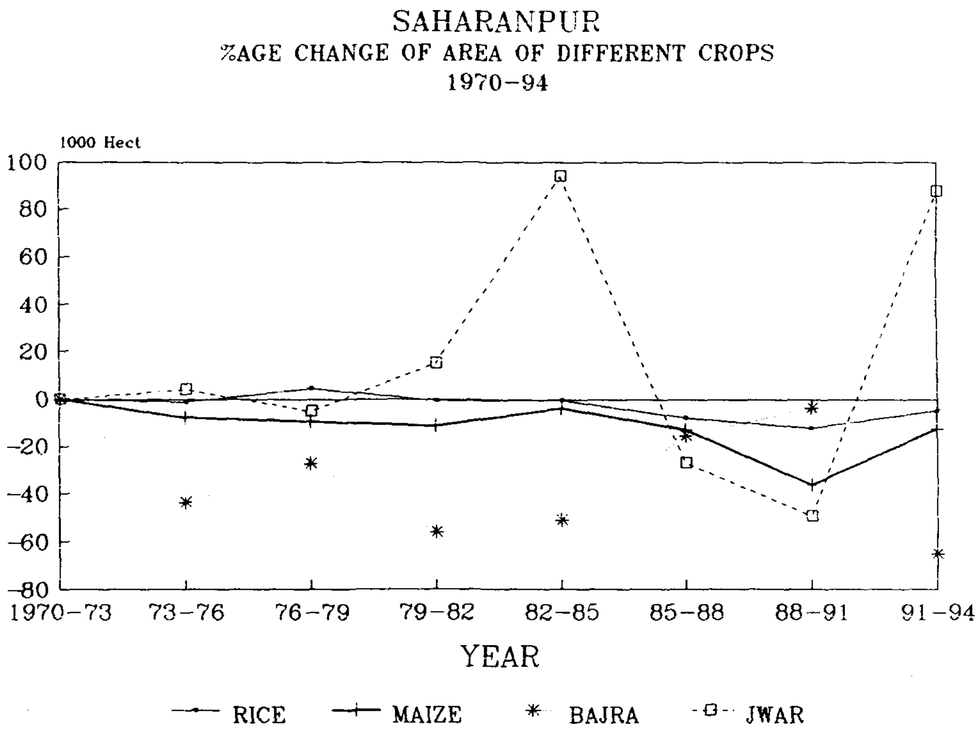
The same Table 3.9A also reveals the percentage of area, simple growth and trend in Muzaffarnagar district. The percentage of area under rice and wheat shows the rising trend from 1976 to 1982 and in case of wheat the trend lines goes above the trend of rice, maize, mustard which is exhibited in Figures 3.9A1, 3.9B1 and 3.9C1. The basic causes of the rising trend in case of wheat are due to the impact of green revolution. But after 1985 the area under wheat, rice and other crops shows a declining trend because the farmers are paying their attention towards the growing of cash crops which are more remunerative than that of the food grain.

TABLE 3.9A

UPPER GANGA-YAMUNA DOAB

%AGE CHANGE OF AREA AND TREND OF SELECTED CROPS (1970-1994)

YEAR	RICE				MAIZE				BAJRA				JWAR				WHEAT			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
									SAHARANPUR											
1970-73	8858	0.00	0.00	8.47	40461	0.00	0.00	2.83	11297	0.00	0.00	0.34	310	0.00	0.00	0.04	172454	0.00	0.00	16.90
1973-76	87707	-1.30	19.05	10.09	37348	-7.69	15.94	2.83	6369	-43.62	7.73	0.37	322	3.98	22.90	0.05	163481	-5.20	19.29	20.16
1976-79	91717	4.57	16.00	11.70	33842	-9.39	13.79	3.28	4645	-27.08	7.18	0.39	306	-5.07	18.63	0.06	175945	7.62	16.17	23.42
1979-82	91040	-0.74	13.80	13.01	30065	-11.16	12.12	3.73	2039	-56.09	6.70	0.42	352	14.92	15.70	0.07	186406	5.95	13.92	26.69
1982-85	90742	-0.33	12.12	14.93	28929	-3.78	10.81	4.18	1002	-50.88	6.28	0.45	682	93.84	13.57	0.08	188858	1.32	12.22	29.95
1985-88	83769	-7.69	10.81	16.54	25286	-12.59	9.75	4.63	848	-15.34	5.91	0.47	499	-26.80	11.59	0.09	187851	-0.53	10.89	33.21
1988-91	73694	-12.03	9.76	18.16	16114	-36.27	8.89	5.09	818	-3.58	5.58	0.50	253	-49.37	10.68	0.10	144890	-22.87	9.82	36.47
1991-94	70200	-4.74	8.89	19.77	14109	-12.44	8.16	5.99	288	-64.82	5.28	0.53	727	87.73	9.65	0.11	132344	-8.86	8.94	39.73
									MUZAFFAR NAGAR											
1970-73	38538	0.00	0.00	4.13	45612	0.00	0.00	1.77	4498	0.00	0.00	0.11	498	0.00	0.00	0.02	157910	0.00	0.00	15.47
1973-76	35021	-9.13	22.67	4.99	22712	-50.21	12.38	1.99	2226	-50.52	6.58	0.12	198	-60.17	10.09	0.02	150370	-4.78	19.81	18.54
1976-79	36712	4.83	17.13	5.84	17761	-21.80	11.02	2.21	1046	-52.99	6.17	0.13	149	-25.04	9.16	0.02	151562	0.79	16.53	21.60
1979-82	44907	22.32	14.62	6.70	16921	-4.73	9.93	2.43	607	-41.99	5.81	0.14	131	-11.66	8.40	0.02	164474	8.52	14.19	24.67
1982-85	40995	-8.71	12.76	7.55	13761	-18.67	9.03	2.65	336	-44.70	5.50	0.15	153	16.24	7.74	0.03	160350	-2.51	12.43	27.73
1985-88	57017	39.08	11.31	8.40	11462	-16.71	8.28	2.87	279	-16.98	5.21	0.16	87	-43.01	7.19	0.03	159492	-0.54	11.05	30.80
1988-91	38606	-32.29	10.16	9.26	8302	-27.57	7.65	3.09	122	-56.22	4.95	0.16	41	-53.26	6.71	0.03	149996	-5.95	9.95	33.87
1991-94	38864	0.67	9.23	10.11	5112	-38.42	7.10	3.31	151	24.04	4.72	0.17	07	-82.79	6.28	0.04	143650	-4.23	9.05	36.93
									MEERUT											
1970-73	25786	0.00	0.00	1.81	72359	0.00	0.00	3.88	18605	0.00	0.00	0.65	2976	0.00	0.00	0.09	228801	0.00	0.00	70.67
1973-76	24272	-5.87	12.24	2.12	71797	-0.78	14.04	4.43	15716	-15.53	8.96	0.71	2219	-25.44	8.75	0.10	229956	0.50	18.13	20.87
1976-79	15908	-34.46	14.71	2.43	33831	-52.88	12.30	4.97	5519	-64.88	8.23	0.77	665	-70.04	8.05	0.11	156763	-31.83	15.35	24.07
1979-82	20291	27.56	12.82	2.74	33883	0.15	10.96	5.52	3943	-28.56	7.60	0.83	411	-38.16	7.44	0.12	166497	6.19	13.31	27.27
1982-85	15578	-23.23	11.37	3.05	30460	-10.02	9.88	6.06	3667	-7.01	7.06	0.89	750	82.48	6.93	0.13	167199	0.43	11.74	30.48
1985-88	14415	7.46	10.21	3.36	26983	-11.42	8.99	6.61	1816	-50.46	6.60	0.95	359	-52.13	6.48	0.14	162026	-3.09	10.51	33.68
1988-91	12744	-11.59	9.26	3.67	24097	-10.69	8.25	7.15	1785	-1.71	6.19	0.10	160	-55.52	6.08	0.15	152120	-6.11	9.51	36.88
1991-94	15436	21.12	8.48	2.98	17242	-28.45	7.62	7.70	1296	527.41	5.83	0.11	184	-15.24	5.74	0.16	149928	-1.44	8.68	40.09
									BULANDSHAHR											
1970-73	8925	0.00	0.00	0.97	119640	0.00	0.00	11.77	35365	0.00	0.00	2.59	11967	0.00	0.00	0.56	202680	0.00	0.00	20.74
1973-76	9254	3.69	90.31	1.16	123126	2.91	20.36	14.16	38329	8.38	16.89	3.03	8937	-25.32	13.76	0.63	195510	3.52	20.35	24.96
1976-79	11241	21.47	16.19	1.35	102450	-16.79	16.92	16.56	23825	-37.40	14.45	3.47	5344	-40.20	12.09	0.71	192690	-1.46	16.91	29.18
1979-82	13960	24.18	13.93	1.53	113565	10.85	14.47	18.93	23411	-1.74	12.63	3.90	4625	-13.46	10.79	0.79	210959	9.48	14.46	33.39
1982-85	8518	-38.99	12.22	1.72	121615	7.09	12.64	21.35	28699	22.59	11.21	4.34	4163	-9.98	9.74	0.86	220944	4.73	12.64	37.61
1985-88	8925	4.78	10.90	1.91	97640	-19.72	11.22	23.75	19663	-31.49	10.08	4.77	2987	-28.26	8.87	0.94	215256	-2.57	11.22	41.83
1988-91	7459	-16.42	9.83	2.09	133142	36.36	10.09	26.14	22419	14.02	9.16	5.22	3349	12.12	8.15	1.02	212043	-1.49	10.09	46.05
1991-94	9316	24.89	8.95	2.28	130491	-2.14	9.16	28.54	15530	-30.73	8.39	5.65	3137	-6.34	7.54	1.09	208767	-1.54	9.16	50.27
									GHAZIABAD											
1976-79	9348	0.00	0.00	0.90	40002	0.00	0.00	3.65	17439	0.00	0.00	1.32	1973	0.00	0.00	0.15	104295	0.00	0.00	10.61
1979-82	9345	-0.03	27.91	1.15	40121	0.30	25.26	4.57	16422	-5.83	22.18	1.62	1935	-1.91	23.61	0.19	110740	6.18	26.84	13.45
1982-85	7232	-22.62	21.82	1.40	38552	-3.91	20.17	5.49	16563	0.86	18.15	1.91	1406	-27.35	19.10	0.22	110910	0.15	21.16	16.30
1985-88	8702	20.33	17.91	1.65	38439	-0.29	16.78	6.41	11693	-29.40	15.36	2.21	1125	-19.96	16.03	0.26	107666	-2.93	17.47	19.15
1988-91	8730	0.32	15.19	1.91	34543	-10.14	14.37	7.34	9747	-16.64	13.32	2.51	1393	23.76	13.82	0.29	130874	3.52	14.87	22.00
1991-94	10683	22.38	13.19	2.16	27246	-21.12	12.57	8.26	7581	-22.23	11.75	2.79	1149	-17.47	12.14	0.33	99073	-4.62	12.94	24.49


SAHARANPUR
%AGE CHANGE OF AREA OF DIFFERENT CROPS
1970-94
1000 Hect
100
80
60
40
20
0
-20
-40
-60
-80
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
BAJRA
JWAR

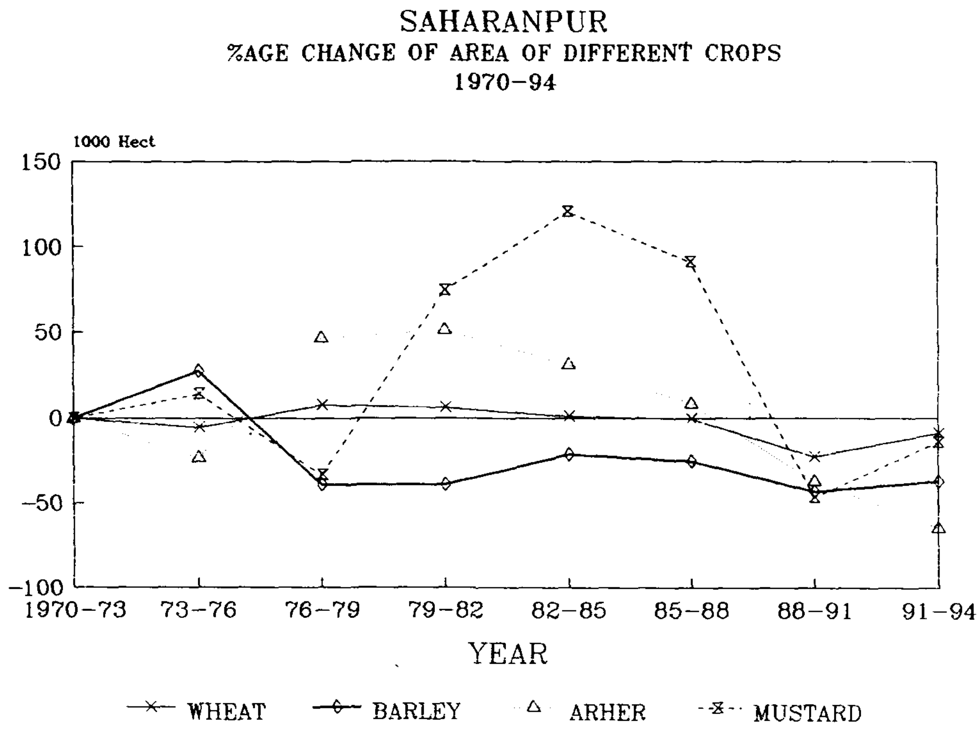

SAHARANPUR
%AGE CHANGE OF AREA OF DIFFERENT CROPS
1970-94
1000 Hect
150
100
50
0
-50
-100
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
WHEAT
BARLEY
ARHER
MUSTARD

Fig. 3.9A

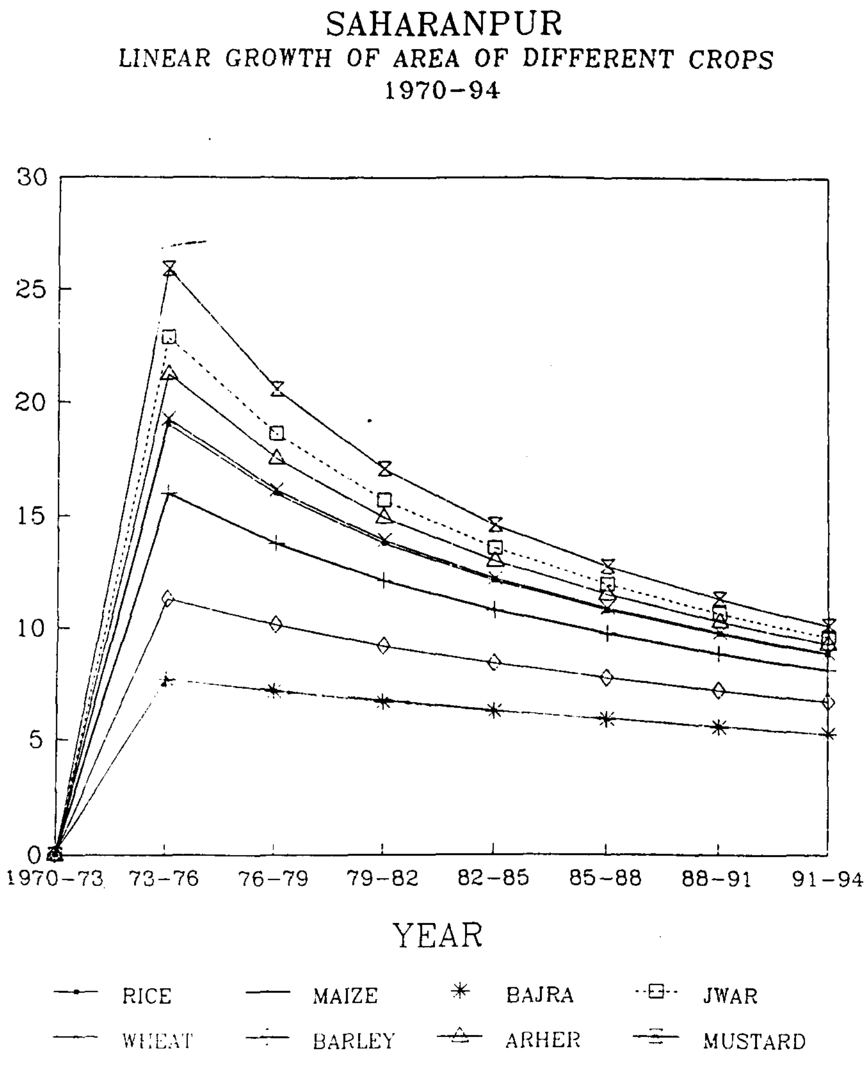


Fig. 3.9B

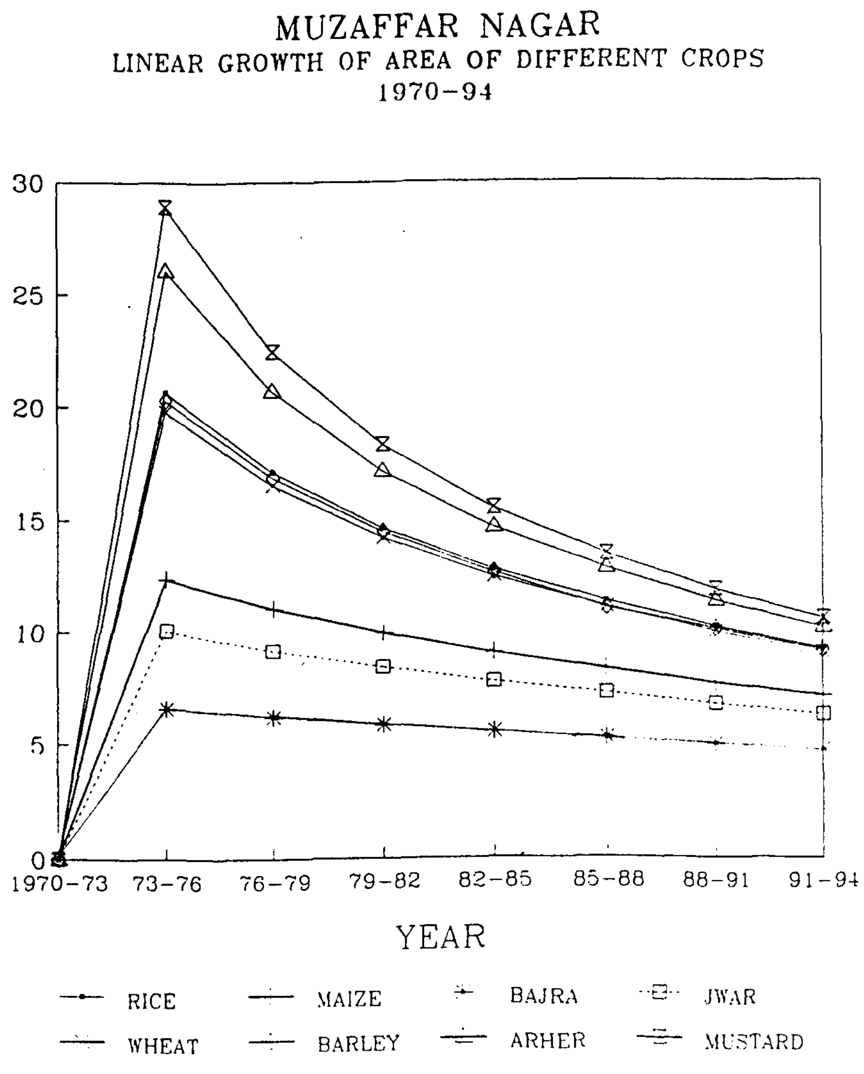
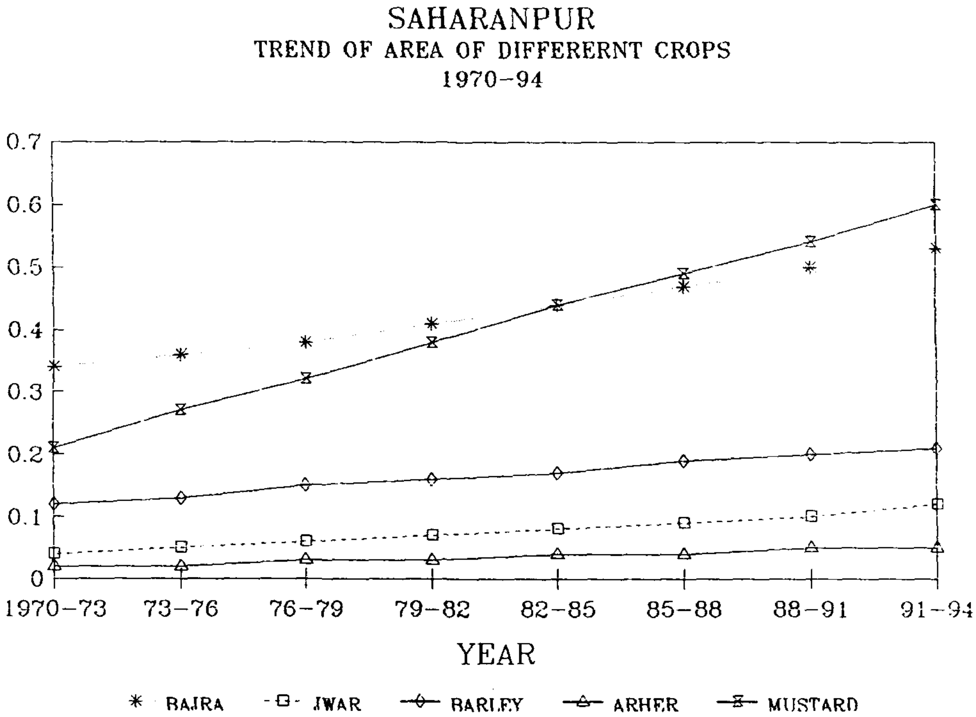
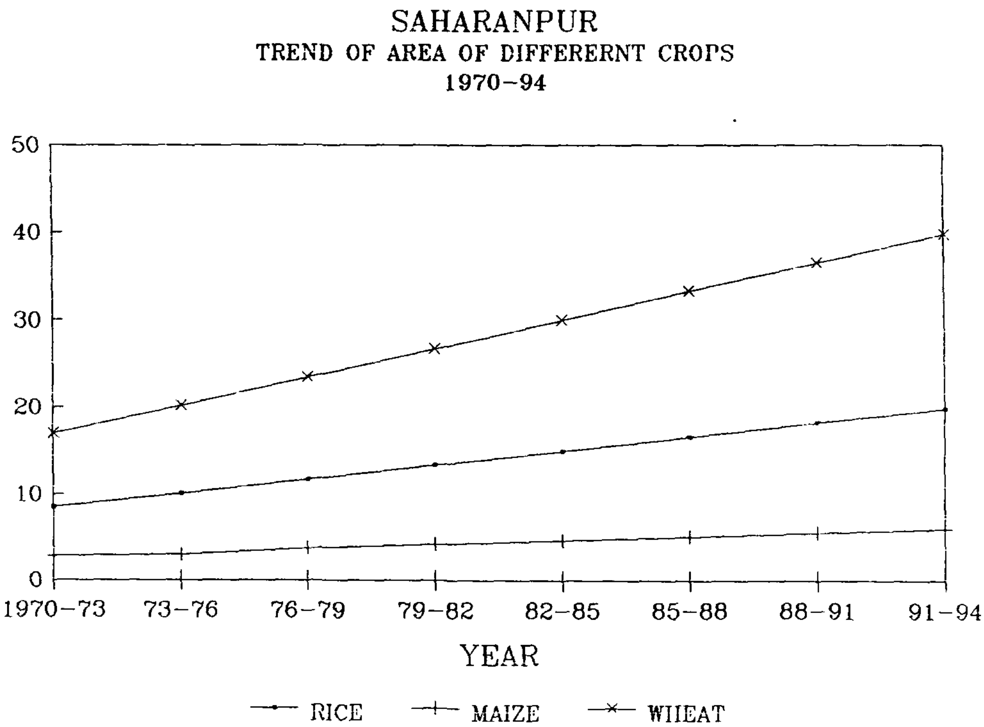


Fig.3.9B1


SAHARANPUR
TREND OF AREA OF DIFFERERNT CROPS
1970-94
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA
JWAR
BARLEY
ARHER
MUSTARD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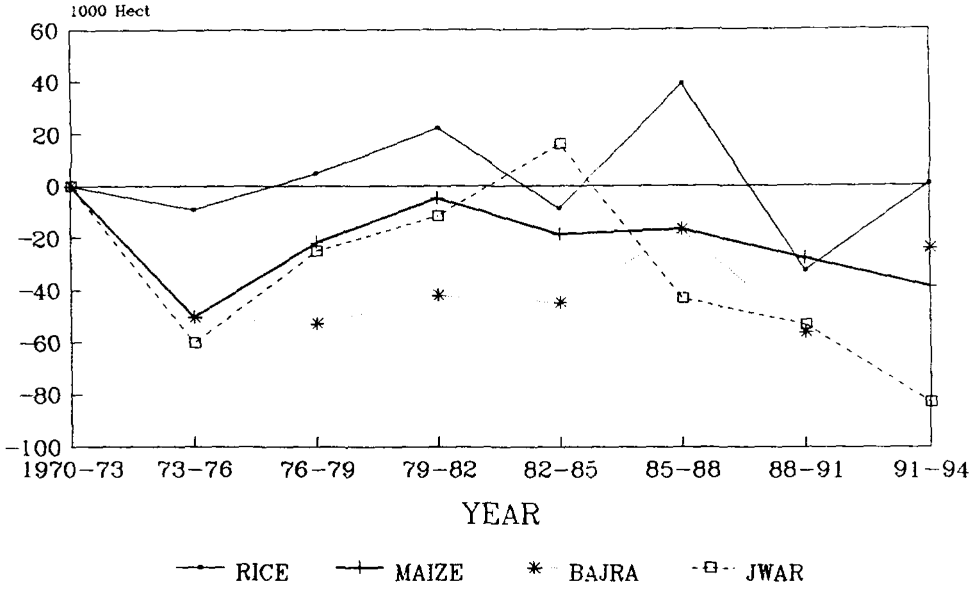
TREND OF AREA OF DIFFERERNT CROPS
1970-94
50
40
30
20
10
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
WHEAT

Fig. 3.9C

MUZAFFAR NAGAR
%AGE CHANGE OF AREA OF DIFFERENT CROPS
1970-94



MUZAFFAR NAGAR
%AGE CHANGE OF AREA OF DIFFERENT CROPS
1970-94

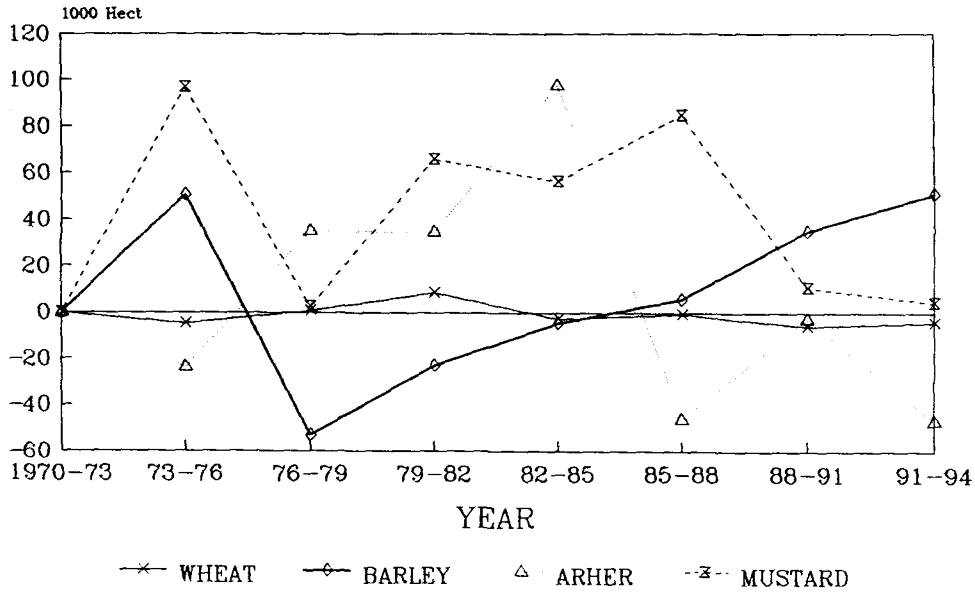
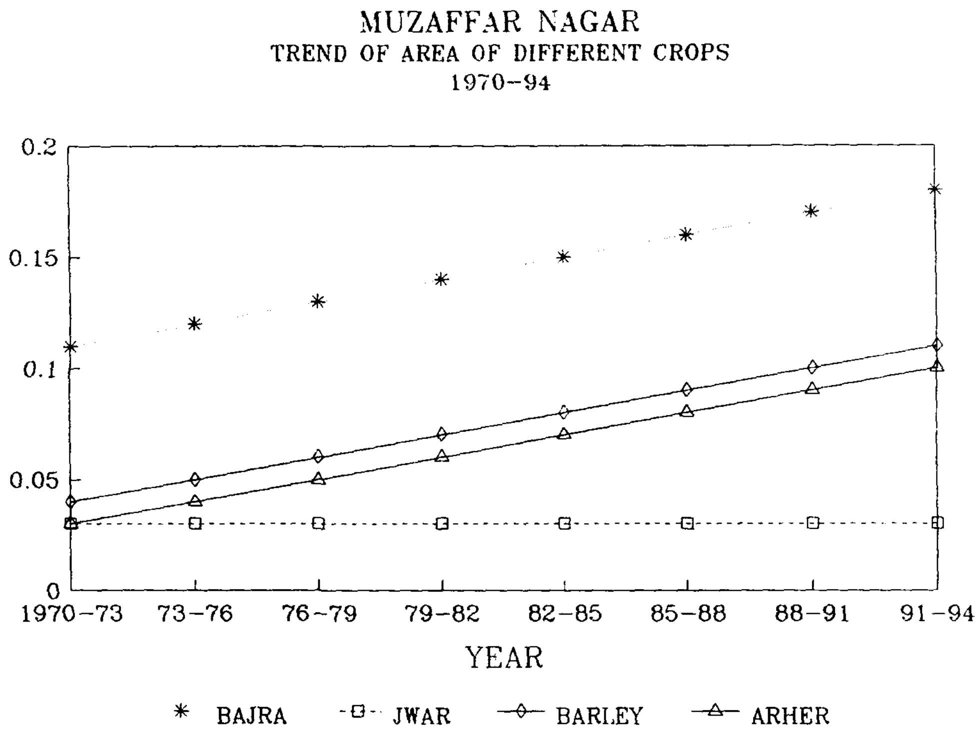


Fig. 3.9A1


MUZAFFAR NAGAR
TREND OF AREA OF DIFFERENT CROPS
1970-94
0.2
0.15
0.1
0.05
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA
JWAR
BARLEY
ARHER

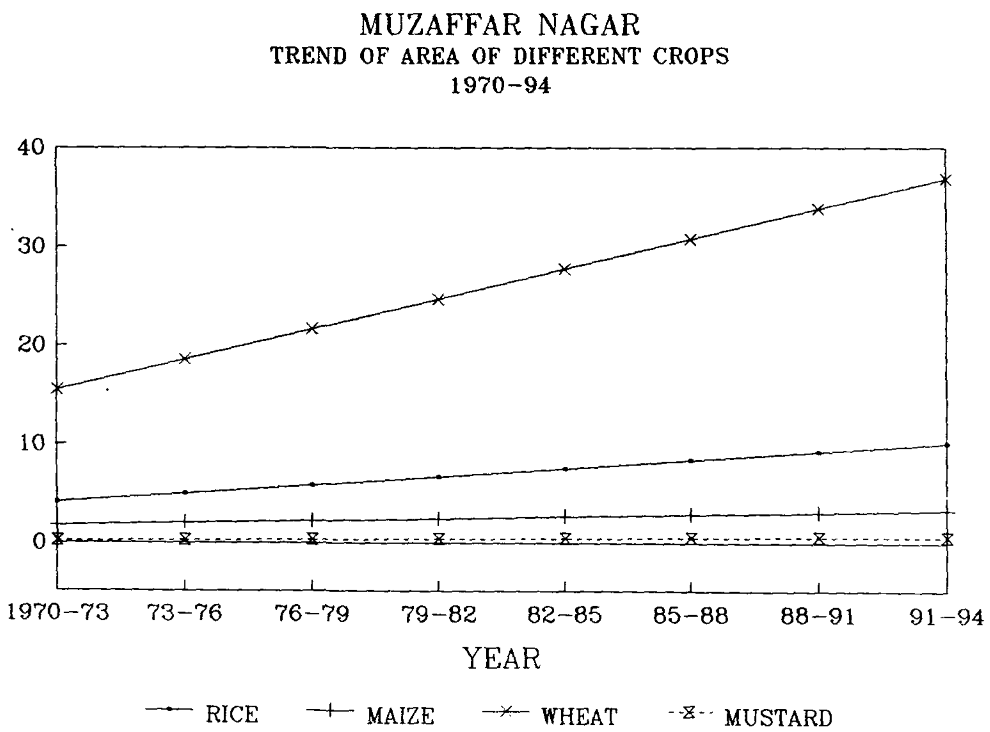

MUZAFFAR NAGAR
TREND OF AREA OF DIFFERENT CROPS
1970-94
40
30
20
10
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
WHEAT
MUSTARD

Fig. 3.9C1

In Meerut district the area under rice and wheat shows the rising trend since 1979 to 1982 in case of rice and it goes upto 1985. Since then the area under wheat is steadily declining. The area under mustard and potato indicate the rising trend from 1979 upto 1994. Figures 3.9A2, B2 and C2 exhibit the percentage change, simple growth and trend of the area. The rising trend of the area under mustard and potato is facilitated due to the rising of price and therefore, the farmers are paying their attention towards the cash crops.

The Table 3.9A and B further reveal the percentage change of the area, simple growth and trend of Bulandshahr district and Ghaziabad. The Figures 3.9A3, B3and C3 show the percentage change, the linear growth and trend of selected crops. The trend of wheat in Bulandshahr district shows almost the similar patterns to Meerut and Muzaffarnagar districts. But in case of rice the area has continuously increased since 1972 to 1982, whereas in Ghaziabad district the area under rice shows increasing trend since 1985 to 1994, but in case of wheat it shows declining trend. In case of potato Bulandshahr and Ghaziabad districts show rising trend since 1970 to 1985 and 1976 to 1991 respectively. This explains the similar features of other districts of Upper Ganga-Yamuna Doab (Figure 3.9A4, B4 and C4).

Table 3.10 and Figures 3.10A, B and C reveal the percentage change of the area, simple growth and trend of selected crops in Upper Ganga-Yamuna Doab since 1976-1977 to 1993-1994 in continuos manner. The analysis of the table shows that wheat predominate over all other crops and the magnitude of area of wheat has declined 2.3 percent since 1970-71 to 1992-93 which is exhibited in Table 3.8. Here due

TABLE 3.9B

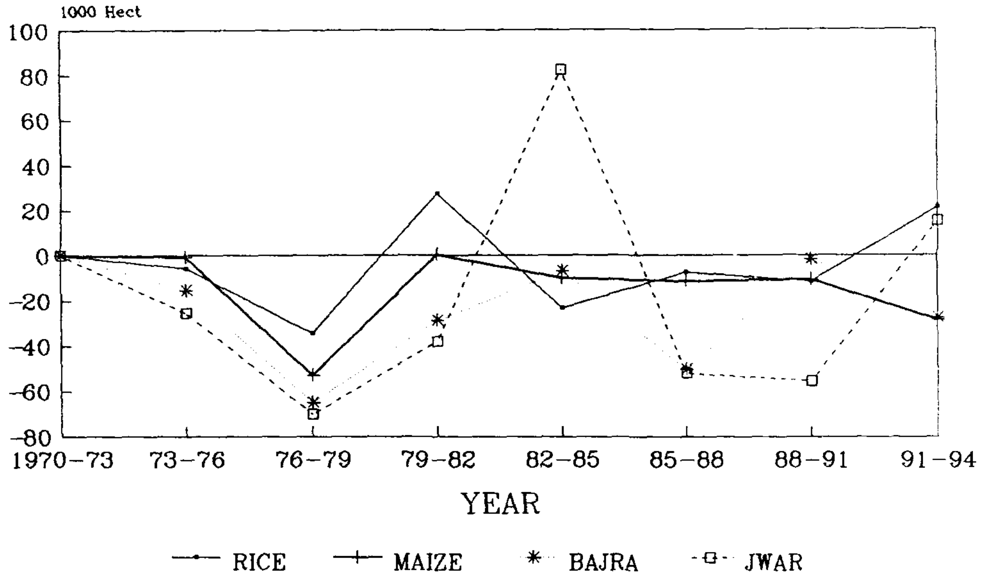
UPPER GANGA-YAMUNA DOAB

%AGE CHANGE OF AREA AND TREND OF SELECTED CROPS (1970-1994)

YEAR	BARLEY				POTATO				SUGARCANE				ARHAR				MUSTARD			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
SAHARANPUR																				
1970-73	2180	0.00	0.00	0.12	709	0.00	0.00	0.13	88028	0.00	0.00	11.33	137	0.00	0.00	0.02	764	0.00	0.00	0.21
1973-76	2794	27.26	11.30	0.13	1277	80.16	21.03	0.15	76217	-13.42	21.52	13.77	105	-23.30	21.29	0.02	1072	40.21	25.93	0.27
1976-79	1694	-38.94	10.16	0.15	1262	-1.23	70.37	0.18	118340	15.27	17.71	16.20	155	46.84	17.55	0.03	714	-33.37	20.52	0.32
1979-82	1029	-39.24	9.22	0.16	1275	1.03	14.80	0.20	114309	-3.41	15.04	18.65	234	51.29	14.93	0.03	1246	74.46	17.08	0.38
1982-85	811	-21.21	8.44	0.18	1615	26.70	12.89	0.23	136829	19.17	13.08	21.08	307	31.20	12.99	0.04	2746	95.44	14.59	0.43
1985-88	605	-25.36	7.78	0.19	1573	-2.58	11.42	0.26	136802	-0.02	11.56	23.52	353	8.36	11.50	0.04	5243	90.95	12.73	0.49
1988-91	344	-43.27	7.22	0.20	1207	-23.26	10.25	0.28	124952	-8.66	10.37	25.95	209	-37.07	10.31	0.05	2804	-46.52	11.29	0.54
1991-94	216	-37.15	6.74	0.22	1088	-9.91	9.30	0.31	110791	-11.33	9.39	28.39	74	-64.50	9.35	0.05	2414	-13.92	10.15	0.60
MUZAFFAR NAGAR																				
1970-73	434	0.00	0.00	0.04	1147	0.00	0.00	0.23	132453	0.00	0.00	17.07	71	0.00	0.00	0.03	336	0.00	0.00	0.19
1973-76	653	50.46	20.32	0.05	3238	82.27	22.38	0.28	148944	12.45	21.46	20.73	54	-23.83	26.08	0.04	661	96.53	28.92	0.25
1976-79	373	-42.83	16.89	0.06	1513	-53.26	18.29	0.34	169162	13.57	17.67	24.40	73	34.97	20.69	0.05	684	3.53	22.44	0.30
1979-82	288	-22.95	14.45	0.07	1919	26.83	15.46	0.39	166123	-1.80	15.01	28.06	245	34.55	17.14	0.06	1135	65.81	18.33	0.36
1982-85	275	-4.40	12.62	0.08	2147	11.86	13.39	0.44	182201	9.68	13.05	31.72	975	97.55	14.63	0.07	1774	56.37	15.49	0.41
1985-88	291	5.82	11.21	0.09	2496	16.27	11.81	0.49	182625	0.23	11.55	35.39	529	-45.76	12.76	0.08	3275	84.56	13.41	0.47
1988-91	393	34.94	10.08	0.10	2907	16.46	10.56	0.54	188969	3.47	10.35	39.05	514	-2.84	11.32	0.09	3630	10.86	11.82	0.53
1991-94	910	80.73	9.16	0.11	3125	7.50	9.55	0.59	195280	3.34	9.38	42.71	273	-46.82	10.17	0.10	3864	6.45	10.57	0.58
MEERUT																				
1970-73	4440	0.00	0.00	0.17	5955	0.00	0.00	0.61	142095	0.00	0.00	15.54	948	0.00	0.00	0.16	430	0.00	0.00	0.24
1973-76	5524	13.15	9.50	0.18	5930	-17.21	22.37	0.74	163377	14.97	20.46	18.72	568	47.63	16.43	0.18	616	52.73	30.37	0.32
1976-79	1003	-18.03	8.67	0.20	3855	-21.60	18.28	0.88	148585	-9.05	16.98	21.89	181	-97.05	14.10	0.21	386	-37.28	23.30	0.39
1979-82	525	-44.98	7.98	0.22	5238	35.53	15.46	1.01	147778	-0.54	14.52	25.07	383	11.61	12.36	0.24	710	83.87	18.89	0.47
1982-85	659	19.44	7.39	0.23	5546	5.88	13.39	1.14	156995	6.23	12.67	28.25	1359	54.74	11.00	0.27	2324	90.17	15.89	0.54
1985-88	544	-70.44	6.88	0.25	6607	19.12	11.80	1.28	154759	-1.42	11.25	31.43	1051	-22.67	9.91	0.29	4952	65.08	13.71	0.62
1988-91	500	-8.14	6.44	0.26	7961	20.49	10.56	1.42	161887	4.61	10.11	34.61	1292	23.00	9.02	0.32	4774	3.59	12.06	0.69
1991-94	767	53.40	6.05	0.28	8305	4.33	9.55	4.55	167529	3.49	9.18	37.79	158	22.77	8.27	0.35	5883	12.75	10.76	0.76
BULANDSHAHR																				
1970-73	26677	0.00	0.00	2.55	4255	0.00	0.00	0.63	44202	0.00	0.00	5.17	2657	0.00	0.00	0.51	1629	0.00	0.00	0.97
1973-76	18158	43.04	18.52	3.02	4874	14.55	21.67	0.76	53702	21.50	19.47	6.18	1565	-41.12	27.14	0.65	2856	75.31	29.51	1.26
1976-79	26419	-30.76	15.63	3.50	5519	13.23	17.81	0.90	61071	13.71	16.30	7.18	1371	-12.36	21.35	0.79	1651	-42.20	22.79	1.55
1979-82	23706	-10.27	13.51	3.97	7276	31.84	15.12	1.03	58116	-4.84	14.01	8.19	4421	22.36	17.59	0.93	4079	-47.08	18.56	1.84
1982-85	17726	-25.23	11.91	4.44	7767	6.74	13.13	1.17	58459	0.59	12.29	9.20	5861	32.56	14.96	1.07	9536	-33.75	15.66	2.12
1985-88	23583	33.34	10.64	4.91	7516	-3.23	11.61	1.30	47735	-18.34	10.95	10.20	8850	50.99	13.01	1.20	20507	15.06	13.54	2.41
1988-91	24449	3.67	9.62	5.39	6397	-14.90	10.40	1.44	45404	4.88	9.87	11.21	4196	-62.58	11.51	1.34	20236	-1.32	11.92	2.70
1991-94	23434	-4.15	8.77	5.86	6409	0.20	9.42	1.57	44868	-1.14	8.98	12.22	11966	85.15	10.33	1.48	17453	-13.75	10.65	2.99
GHAZIABAD																				
1976-79	4525	0.00	0.00	0.35	3813	0.00	0.00	0.54	46532	0.00	0.00	5.04	289	0.00	0.00	0.15	162	0.00	0.00	0.24
1979-82	3331	-26.39	25.61	0.44	4798	25.85	29.75	0.70	48477	4.18	27.98	6.45	577	97.35	39.65	0.22	388	39.01	40.10	0.34
1982-85	2920	-12.32	20.39	0.53	5375	12.02	22.93	0.86	52767	4.85	21.87	7.86	951	66.49	28.39	0.28	1752	51.63	28.62	0.44
1985-88	3737	27.94	16.93	0.62	6162	14.64	18.65	1.01	50061	-5.13	17.94	9.28	1159	21.91	22.11	0.35	3958	25.89	22.25	0.54
1988-91	3204	-14.25	14.48	0.70	6427	4.30	15.72	1.17	51658	3.19	15.21	10.68	4070	51.19	18.10	0.41	3789	-4.28	18.20	0.63
1991-94	3160	-1.37	12.65	0.79	5597	-12.91	13.58	1.33	53048	2.68	13.20	12.10	2458	-39.61	15.33	0.47	4538	19.75	15.40	0.73

NOTE : A = AREA, B = SIMPLE GROWTH, C = LINEAR GROWTH, D = TREND

MEERUT
%AGE CHANGE OF AREA OF DIFFERENT CROPS
1970-94



MEERUT
%AGE CHANGE OF AREA OF DIFFERENT CROPS
1970-94

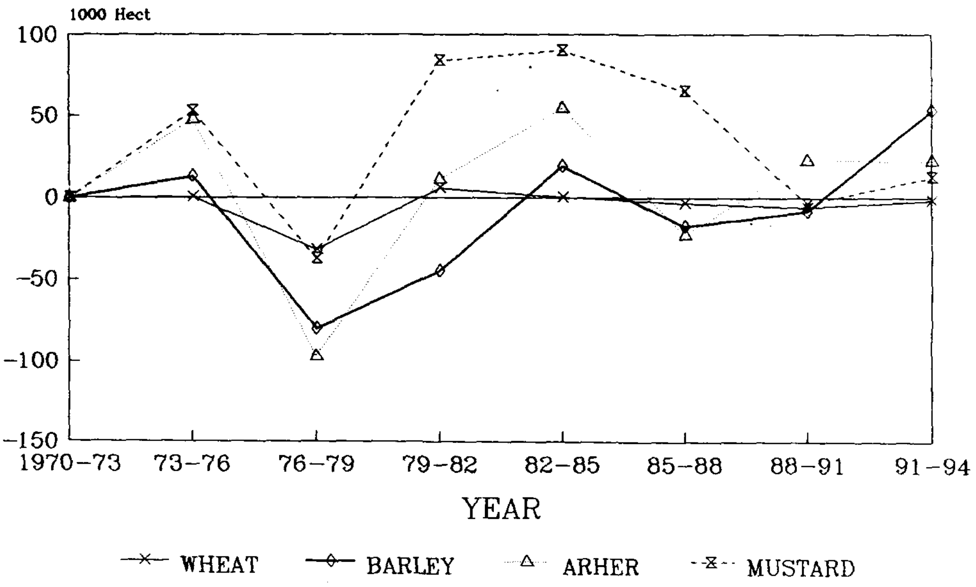
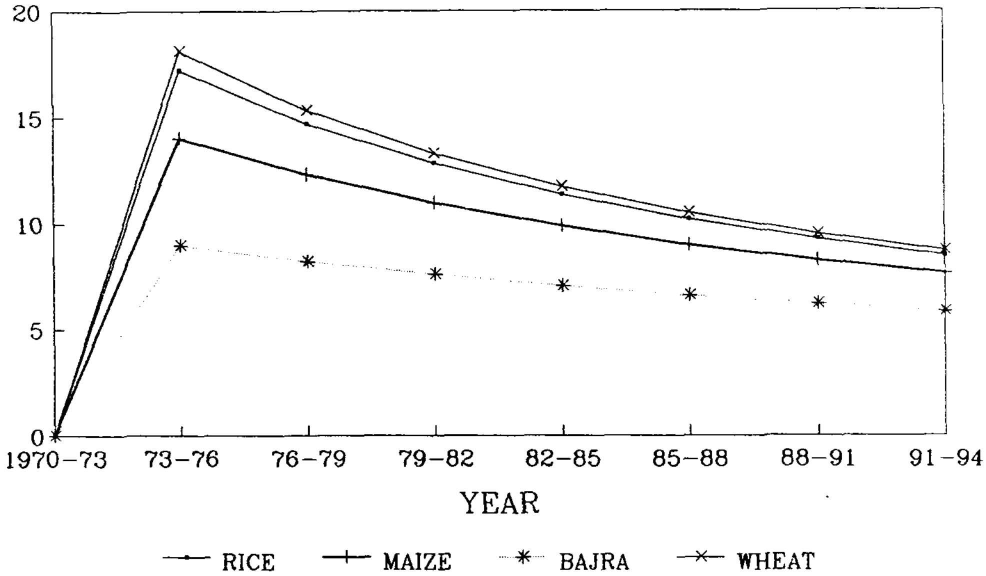


Fig. 3.9A2

MEERUT
LINEAR GROWTH OF AREA OF DIFFERENT CROPS
1970-94



MEERUT
LINEAR GROWTH OF AREA OF DIFFERENT CROPS
1970-94

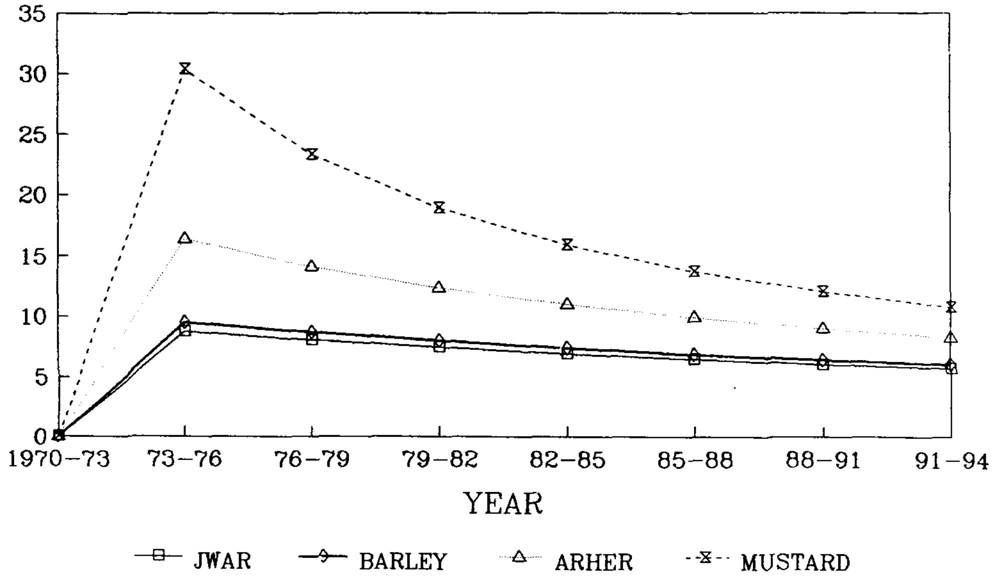
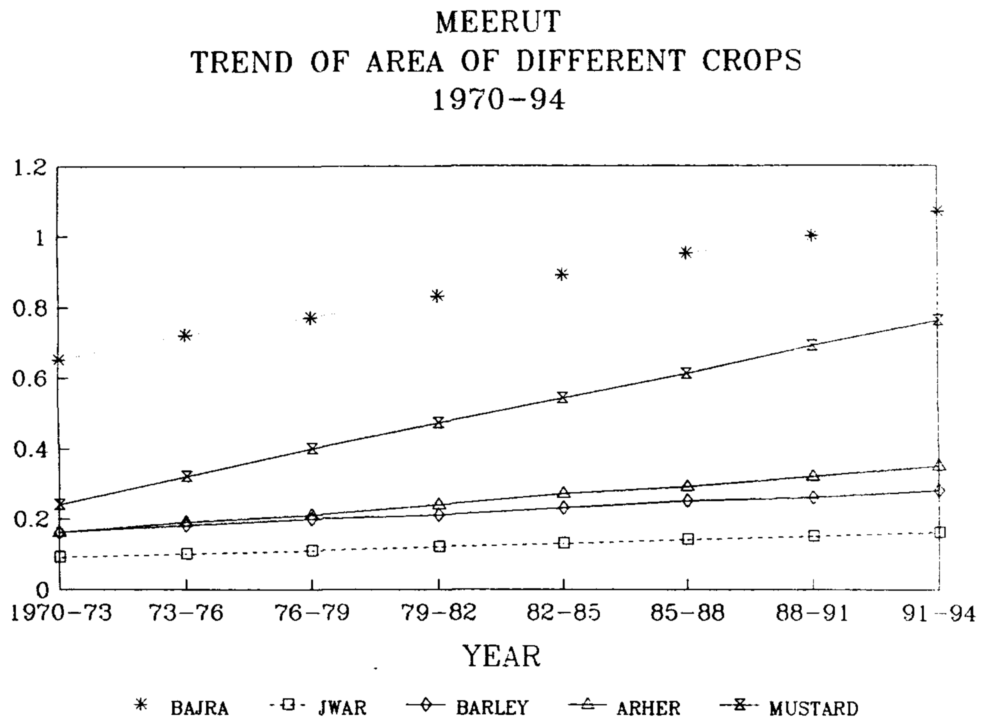


Fig. 3.9B2


MEERUT
TREND OF AREA OF DIFFERENT CROPS
1970-94
1.2
1
0.8
0.6
0.4
0.2
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA
JWAR
BARLEY
ARHER
MUSTARD

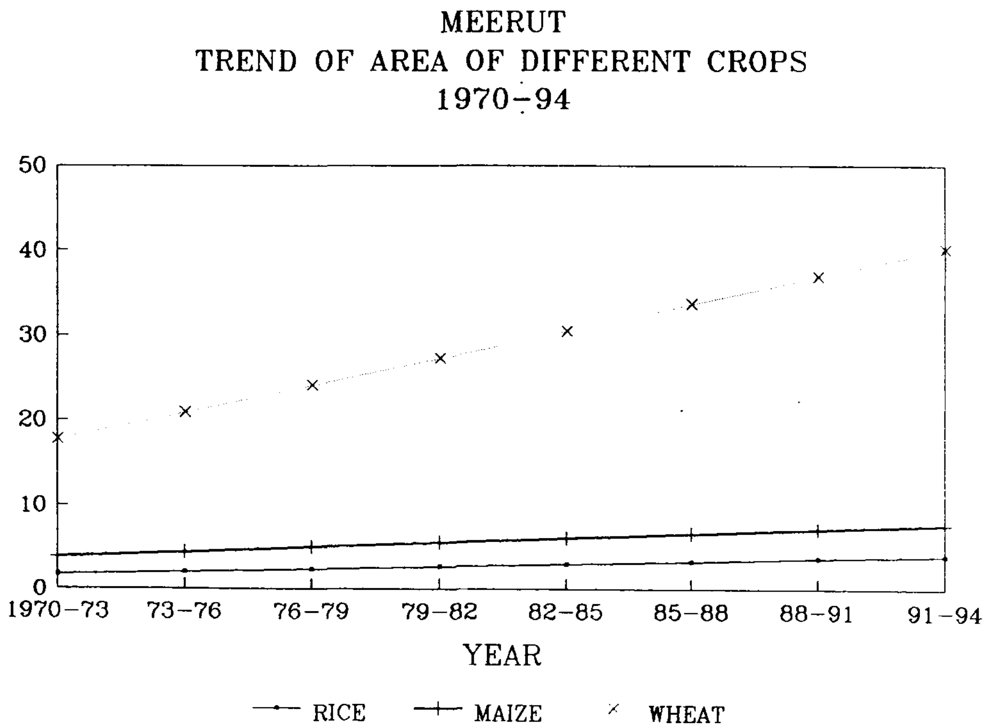
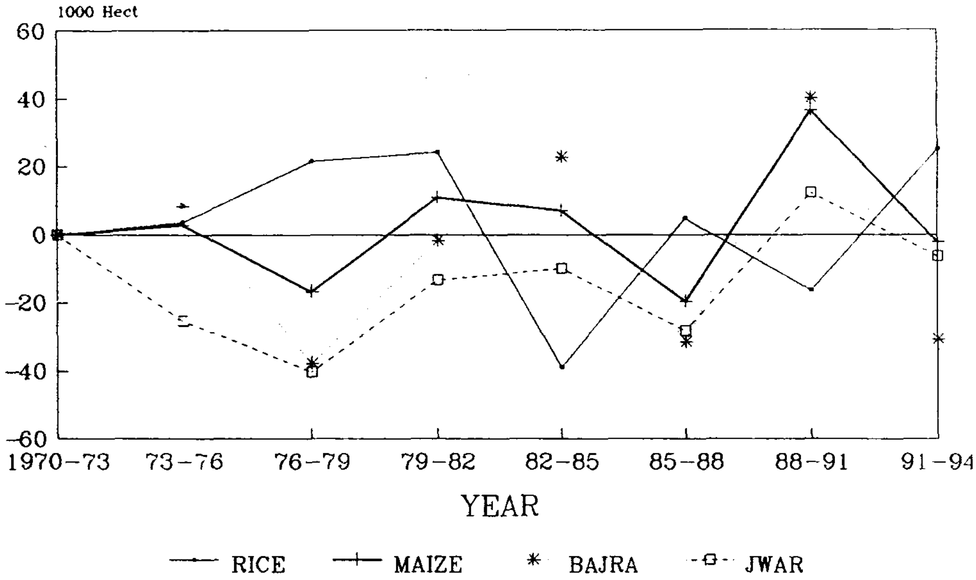

MEERUT
TREND OF AREA OF DIFFERENT CROPS
1970-94
50
40
30
20
10
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
WHEAT

Fig. 3.9C2

BULANDSHAHAR
%AGE CHANGE OF AREA OF DIFFERENT CROPS
1970-94



BULANDSHAHAR
%AGE CHANGE OF AREA OF DIFFERENT CROPS
1970-94

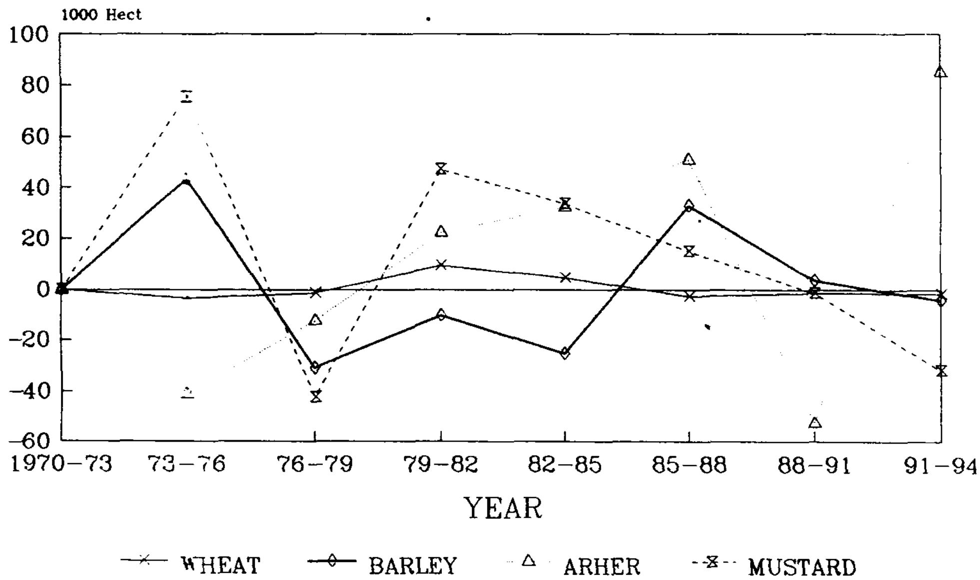
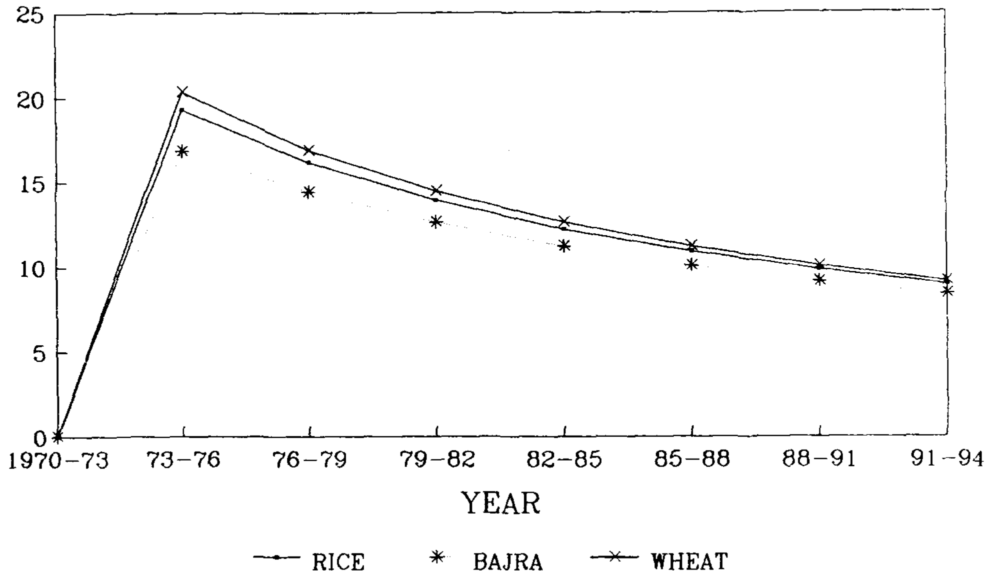


Fig. 3.9A3

BULANDSHAHAR
LINEAR GROWTH OF AREA OF DIFFERENT CROPS
1970-94



BULANDSHAHAR
LINEAR GROWTH OF AREA OF DIFFERENT CROPS
1970-94

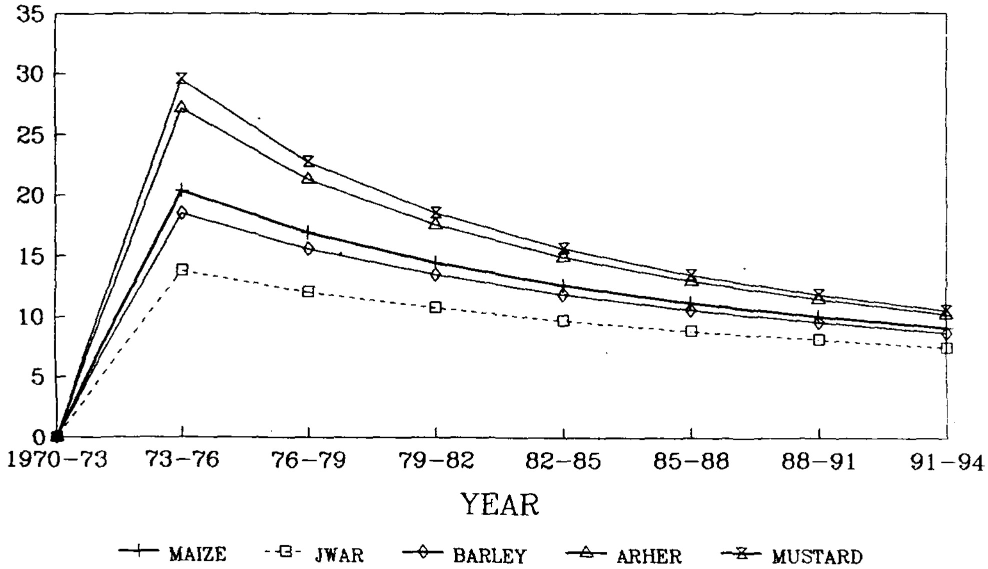
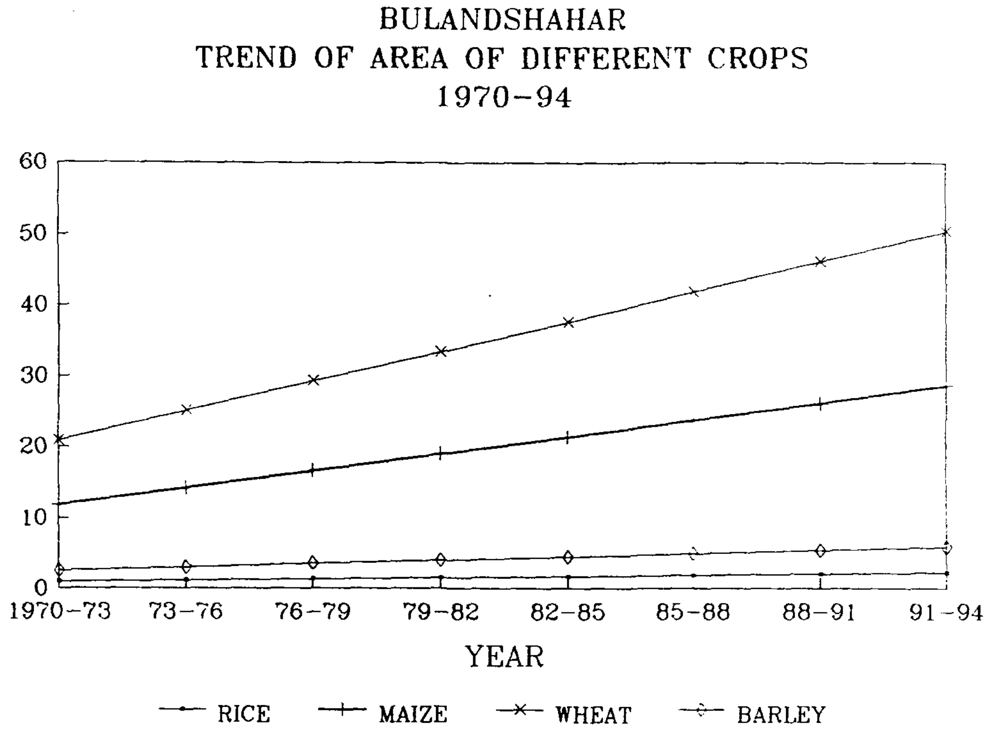


Fig. 3.9B3


BULANDSHAHAR
TREND OF AREA OF DIFFERENT CROPS
1970-94
60
50
40
30
20
10
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
WHEAT
BARLEY

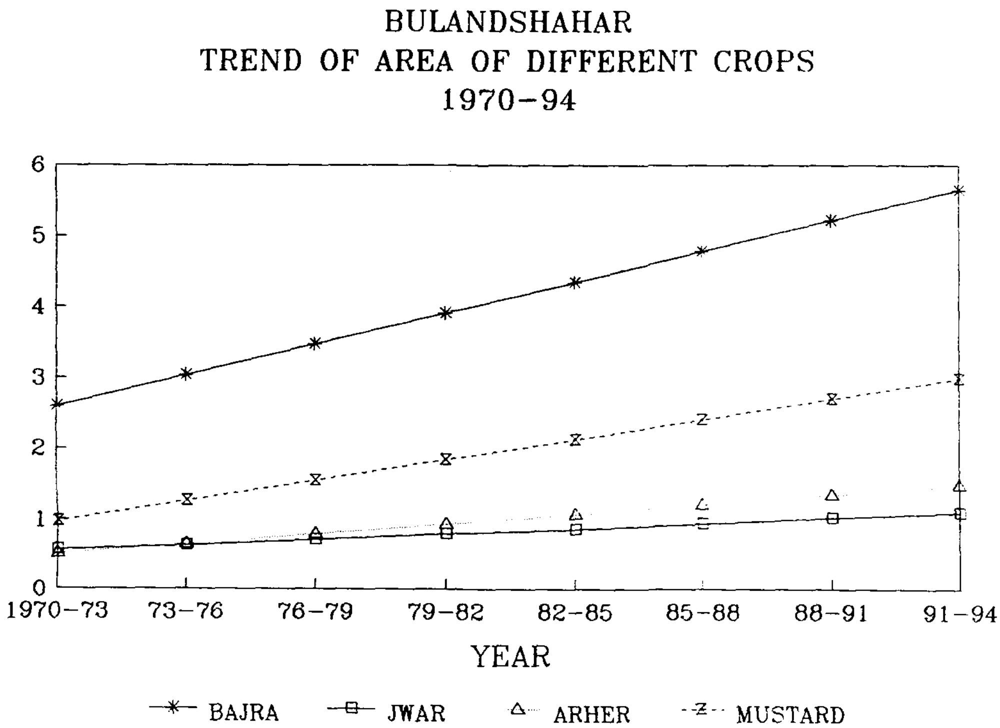
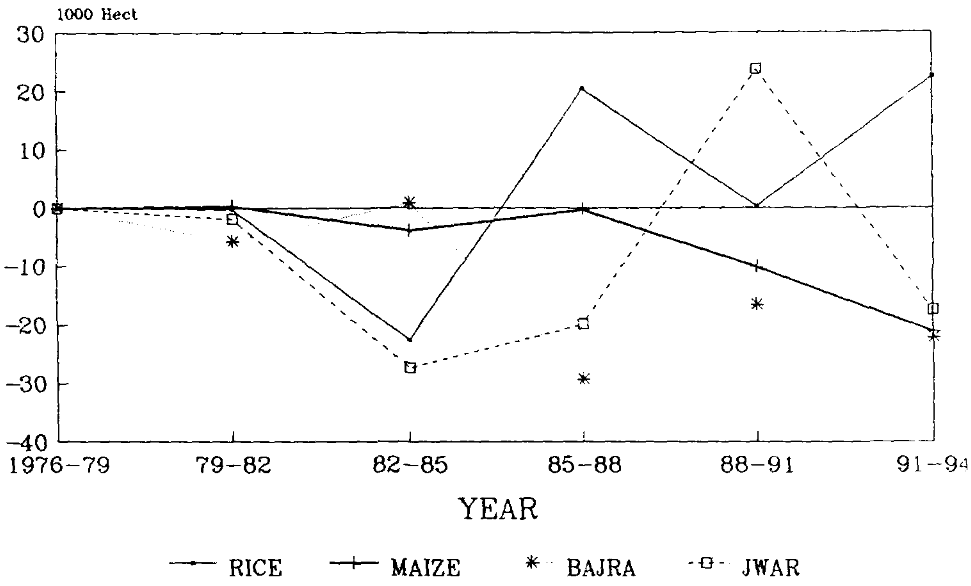

BULANDSHAHAR
TREND OF AREA OF DIFFERENT CROPS
1970-94
6
5
4
3
2
1
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA
JWAR
ARHER
MUSTARD

Fig. 3.9C3

GHAZIABAD
%AGE CHANGE OF AREA OF DIFFERENT CROPS
1976-94



GHAZIABAD
%AGE CHANGE OF AREA OF DIFFERENT CROPS
1976-94

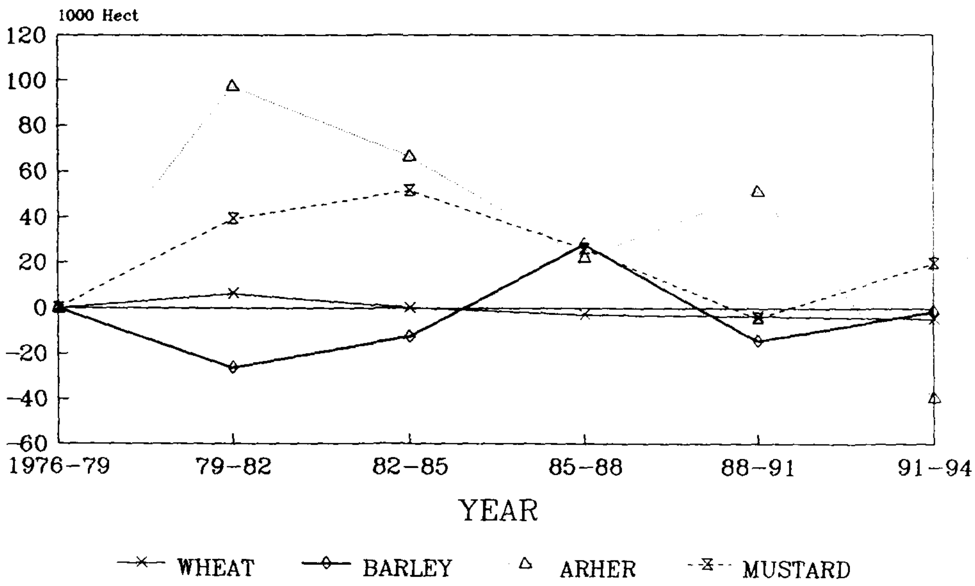
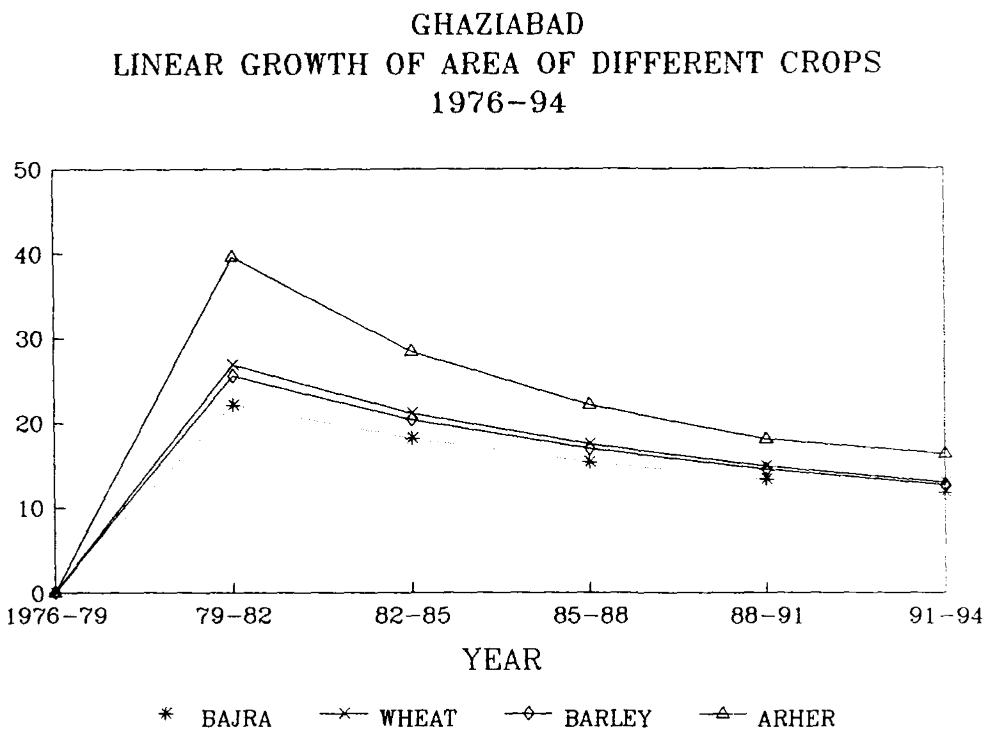


Fig. 3.9A4


GHAZIABAD
LINEAR GROWTH OF AREA OF DIFFERENT CROPS
1976-94
50
40
30
20
10
0
1976-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA
WHEAT
BARLEY
ARHER

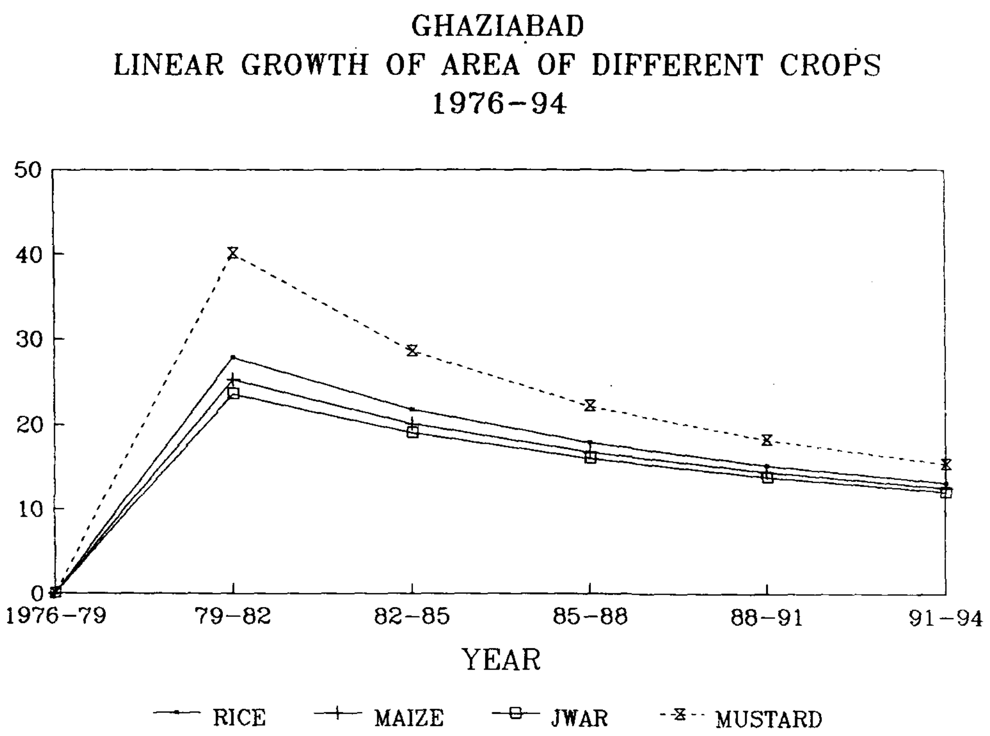
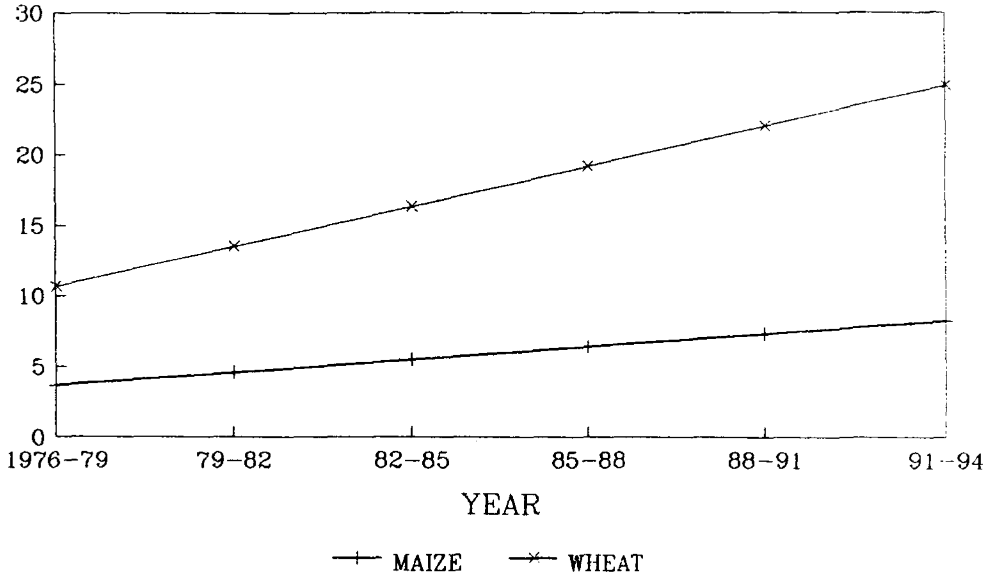

GHAZIABAD
LINEAR GROWTH OF AREA OF DIFFERENT CROPS
1976-94
50
40
30
20
10
0
1976-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
JWAR
MUSTARD

Fig. 3.9B4

GHAZIABAD
TREND OF AREA OF DIFFERENT CROPS
1976-94



GHAZIABAD
TREND OF AREA OF DIFFERENT CROPS
1976-94

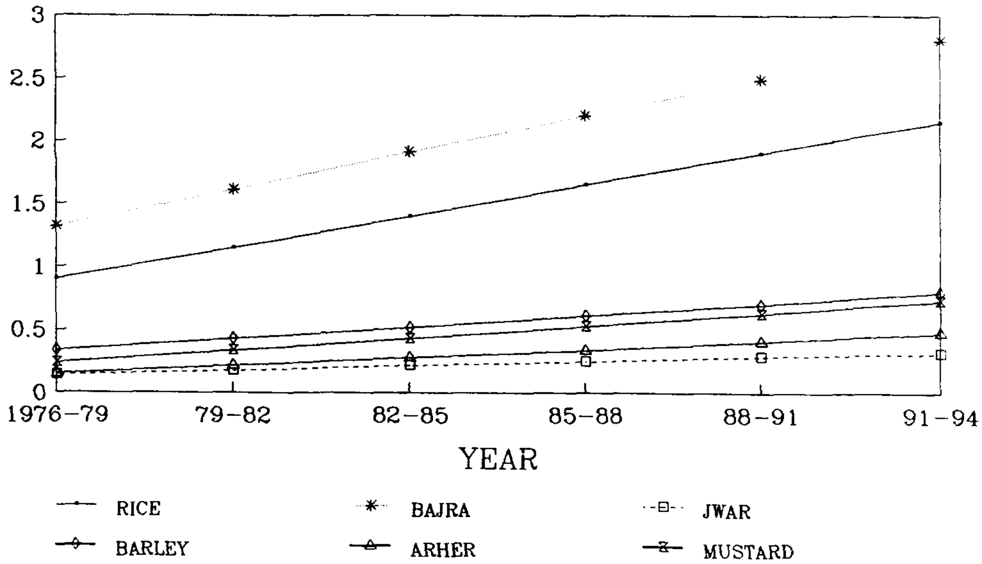


Fig. 3.9C4

TABLE 3.10

UPPER GANGA-YAMUNA DOAB

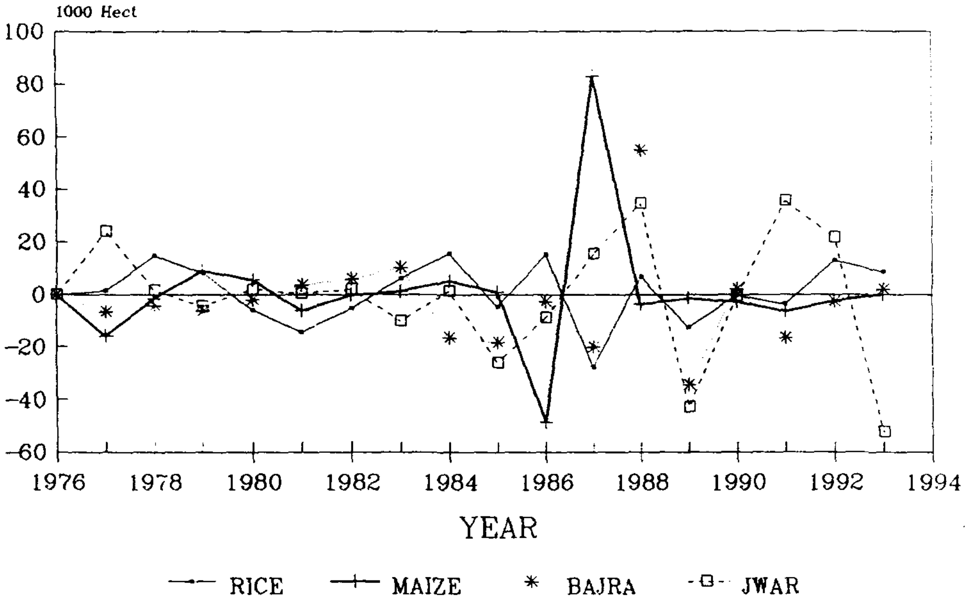
%AGE CHANGE OF AREA AND TREND OF SELECTED CROPS (1976-1994)

YEAR	RICE				MAIZE				BAJRA				JWAR				WHEAT			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
1976-77	155676	0.00	0.00	16.02	256414	0.00	0.00	21.76	55746	0.00	0.00	4.05	9947	0.00	0.00	0.64	626112	0.00	0.00	79.14
1977-78	157860	1.40	8.25	17.43	215404	-15.99	8.26	23.56	51925	-6.85	6.41	4.35	7554	-24.06	7.53	0.69	751272	19.99	8.51	85.88
1978-79	181238	14.81	67.62	18.76	211841	-1.65	87.62	25.66	49751	-4.19	6.02	4.65	7685	1.73	7.00	0.74	801815	6.72	7.84	92.62
1979-80	196420	8.38	7.08	20.09	221168	9.12	7.09	27.15	46488	-6.56	5.68	4.95	7345	-4.42	6.54	0.79	845196	5.41	7.27	99.36
1980-81	184435	-6.10	6.61	21.41	243966	5.54	6.62	28.95	45579	-1.96	5.38	5.25	7479	1.82	6.14	0.84	849700	0.53	6.78	106.09
1981-82	157776	-14.45	6.20	22.74	228537	-6.33	6.21	30.35	47199	3.55	5.10	5.54	7507	0.38	5.79	0.88	830362	-2.28	6.35	112.83
1982-83	148925	-5.61	5.84	24.07	227655	-0.38	5.84	32.54	49925	5.76	4.85	5.84	7656	1.98	5.47	0.93	828544	-0.22	5.97	119.57
1983-84	157909	6.03	5.52	25.40	230308	1.17	5.52	34.34	55042	10.25	4.63	6.14	6873	-10.23	5.18	0.91	853714	3.04	5.64	126.31
1984-85	182357	15.48	5.23	26.72	241989	5.07	5.23	36.14	55821	-16.74	4.42	6.44	6952	1.29	4.93	1.03	854081	0.04	5.33	133.05
1985-86	173749	-4.72	4.97	28.05	244424	1.01	4.97	37.93	37450	-18.29	4.24	6.74	5146	-26.08	4.17	1.07	844514	-1.12	5.06	139.78
1986-87	200191	15.21	4.73	29.38	125512	-48.65	4.74	39.73	36368	-2.89	4.06	7.03	4687	-8.92	4.49	1.12	843282	-0.15	4.82	146.52
1987-88	144544	-27.79	4.52	30.71	229495	82.85	4.52	41.53	29079	-20.04	3.91	7.33	5418	15.60	4.30	1.17	822305	-2.49	4.60	153.26
1988-89	154555	6.93	4.32	32.04	220613	-3.87	4.33	43.32	45014	54.80	3.76	7.63	7294	34.63	4.12	1.22	814356	-0.97	4.40	159.99
1989-90	134823	-12.77	4.15	33.36	217026	-1.63	4.15	45.12	29528	-34.40	3.62	7.93	4158	-42.99	3.60	1.27	749234	-7.99	4.21	166.73
1990-91	134620	-0.37	3.98	34.69	210955	-2.80	3.98	46.92	30135	2.05	3.50	8.22	4132	-0.63	3.81	1.32	734709	-1.94	4.04	173.47
1991-92	129126	-3.87	3.82	36.02	197427	-6.41	3.83	48.72	25131	-16.60	3.38	8.52	5597	35.46	3.67	1.37	719393	-2.08	3.88	180.21
1992-93	145879	12.98	3.69	37.35	197385	-2.55	3.69	50.51	24455	-2.69	3.31	8.82	6813	21.73	3.54	1.41	732307	1.80	3.74	186.95
1993-94	158480	8.63	3.56	38.68	192190	-0.10	3.56	52.31	24952	2.03	3.35	9.12	3245	-62.37	3.42	1.46	744917	1.72	3.60	193.69

YEAR	BARLEY				POTATO				SUGARCANE				ARHAR				MUSTARD			
1976-77	40081	0.00	0.00	2.85	12764	0.00	0.00	2.21	507747	0.00	0.00	56.37	1948	0.00	0.06	0.93	3137	0.00	0.00	2.27
1977-78	32271	-19.48	8.36	3.09	13269	3.95	9.28	2.42	575626	13.37	8.69	61.27	2082	6.88	11.02	1.04	4464	42.30	11.42	2.53
1978-79	29376	-8.97	7.71	3.33	21882	64.91	8.49	2.62	547696	-4.85	7.99	66.16	2179	4.66	9.93	1.14	3193	-28.47	10.25	2.79
1979-80	23828	-18.89	7.16	3.57	18834	-13.93	7.83	2.83	495699	-10.22	7.40	71.06	4005	83.80	9.03	1.24	3034	-4.98	9.30	3.05
1980-81	30352	27.38	6.68	3.80	20661	9.70	7.26	3.03	517047	5.16	6.89	75.96	7631	90.54	8.28	1.34	8686	54.29	8.51	3.30
1981-82	32538	7.20	6.26	4.04	22026	6.61	6.77	3.24	595661	15.20	6.45	80.86	5928	-22.32	7.65	1.45	10954	26.11	7.84	3.56
1982-83	22551	-30.69	5.90	4.30	20102	-8.74	6.34	3.44	607565	1.99	6.06	85.76	8426	42.14	7.11	1.55	12014	9.68	7.27	3.82
1983-84	21755	-3.52	5.57	4.52	21857	8.73	5.96	3.65	589971	-2.90	5.71	90.65	10967	30.16	6.64	1.65	11839	-1.46	6.78	4.08
1984-85	22939	5.44	5.27	4.76	25392	16.17	5.62	3.85	564223	-4.36	5.40	95.55	8965	-18.25	6.22	1.75	30544	57.99	6.35	4.34
1985-86	30119	31.30	5.01	4.99	23843	-6.10	5.33	4.06	540422	-4.22	5.13	100.45	12365	37.93	5.86	1.86	42408	38.84	5.97	4.60
1986-87	28269	-6.14	4.77	5.23	22845	-4.19	5.06	4.26	575002	6.40	4.88	105.34	11114	-10.12	5.53	1.96	34869	-17.78	5.63	4.86
1987-88	27874	-1.40	4.55	5.46	26375	15.45	4.81	4.67	600523	4.44	4.65	110.02	12285	10.54	5.24	2.06	30530	4.76	5.33	5.12
1988-89	30303	8.71	4.35	5.71	26039	-1.27	4.59	4.68	599333	-0.20	4.44	215.14	4334	-64.72	4.98	2.16	38027	4.10	5.06	5.38
1989-90	27310	-9.88	4.17	5.95	24273	-6.78	4.39	4.88	548740	-8.44	4.25	120.04	13003	20.02	4.75	2.27	34632	-8.93	4.82	5.63
1990-91	28850	5.63	4.01	6.18	24384	0.46	4.20	5.08	570538	8.97	4.08	124.94	13510	3.90	4.53	2.37	33042	-4.59	4.60	5.89
1991-92	29520	2.32	3.85	6.42	24901	2.12	4.04	5.29	581784	1.97	3.92	129.84	14876	10.11	4.33	2.47	34623	4.78	4.39	6.16
1992-93	26806	9.19	3.71	6.66	23544	-5.45	3.88	5.50	574016	-1.34	3.77	134.73	15590	4.80	4.15	2.57	32790	-5.29	4.21	6.41
1993-94	28231	5.32	3.58	6.90	25128	6.73	3.73	5.70	558801	-2.65	3.64	143.63	18608	19.36	3.99	2.68	33544	2.30	4.04	6.67

NOTE : A = AREA, B = SIMPLE GROWTH, C = LINEAR GROWTH, D = TREND

UPPER GANGA YAMUNA DOAB
%AGE CHANGE OF AREA OF DIFFERENTS CROPS
(1976-94)



UPPER GANGA YAMUNA DOAB
%AGE CHANGE OF AREA OF DIFFERENTS CROPS
(1976-94)

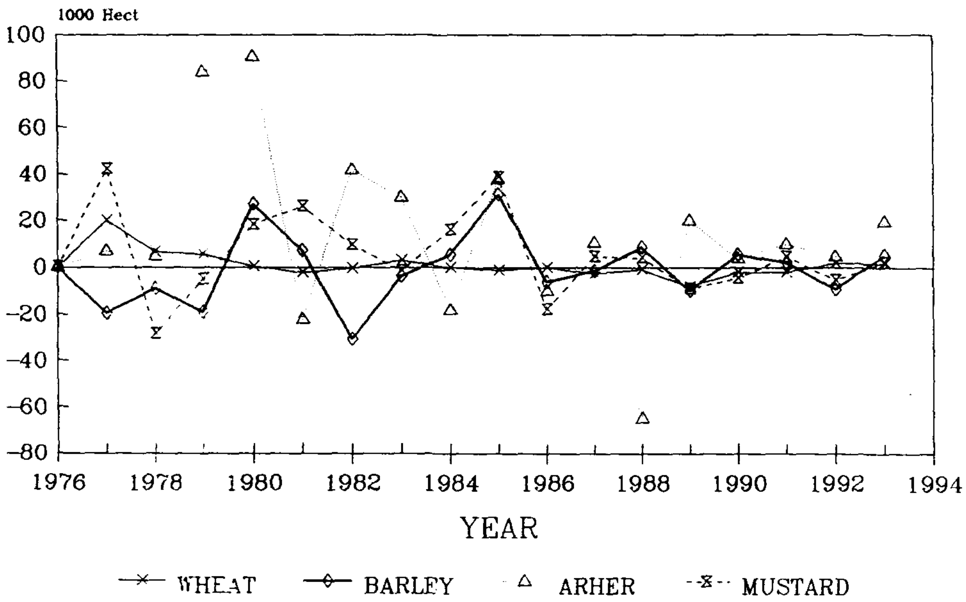
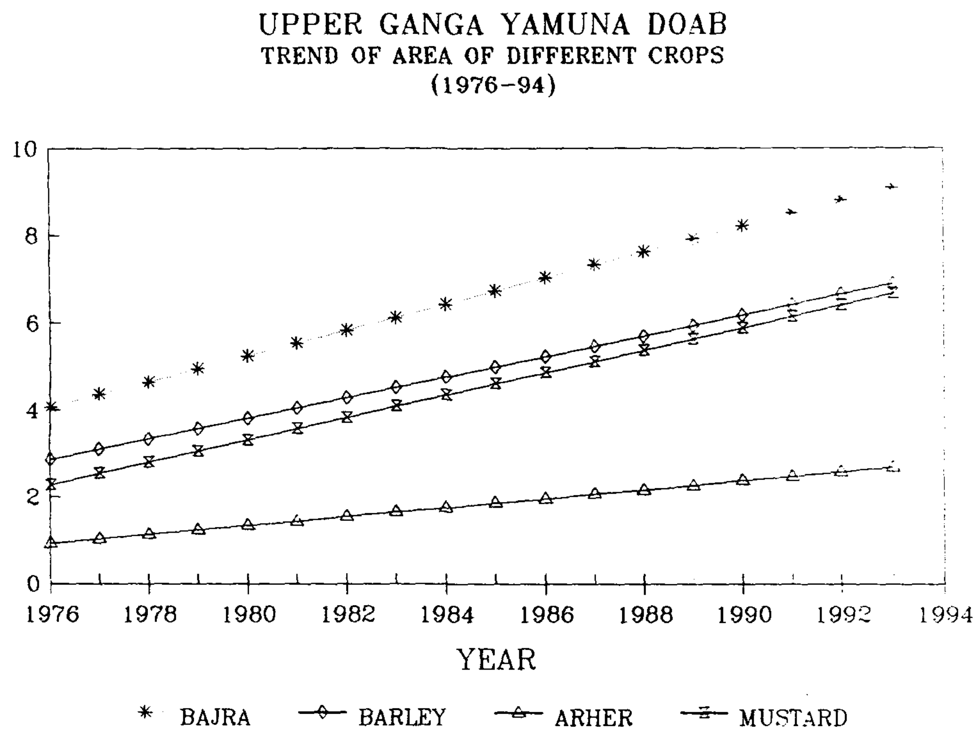


Fig. 3.10A


UPPER GANGA YAMUNA DOAB
TREND OF AREA OF DIFFERENT CROPS
(1976-94)
10
8
6
4
2
0
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
YEAR
BAJRA
BARLEY
ARHER
MUSTARD

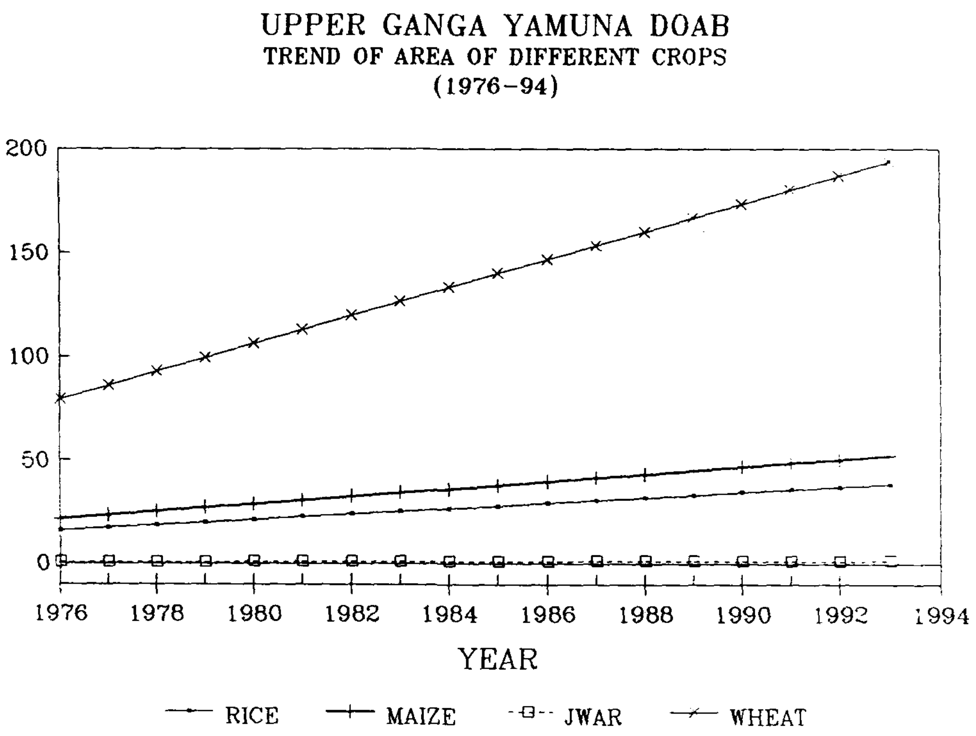

UPPER GANGA YAMUNA DOAB
TREND OF AREA OF DIFFERENT CROPS
(1976-94)
200
150
100
50
0
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
YEAR
RICE
MAIZE
JWAR
WHEAT

Fig. 3.10B

UPPER GANGA YAMUNA DOAB

LINEAR GROWTH OF AREA OF DIFFERENT CROPS

(1976-94)

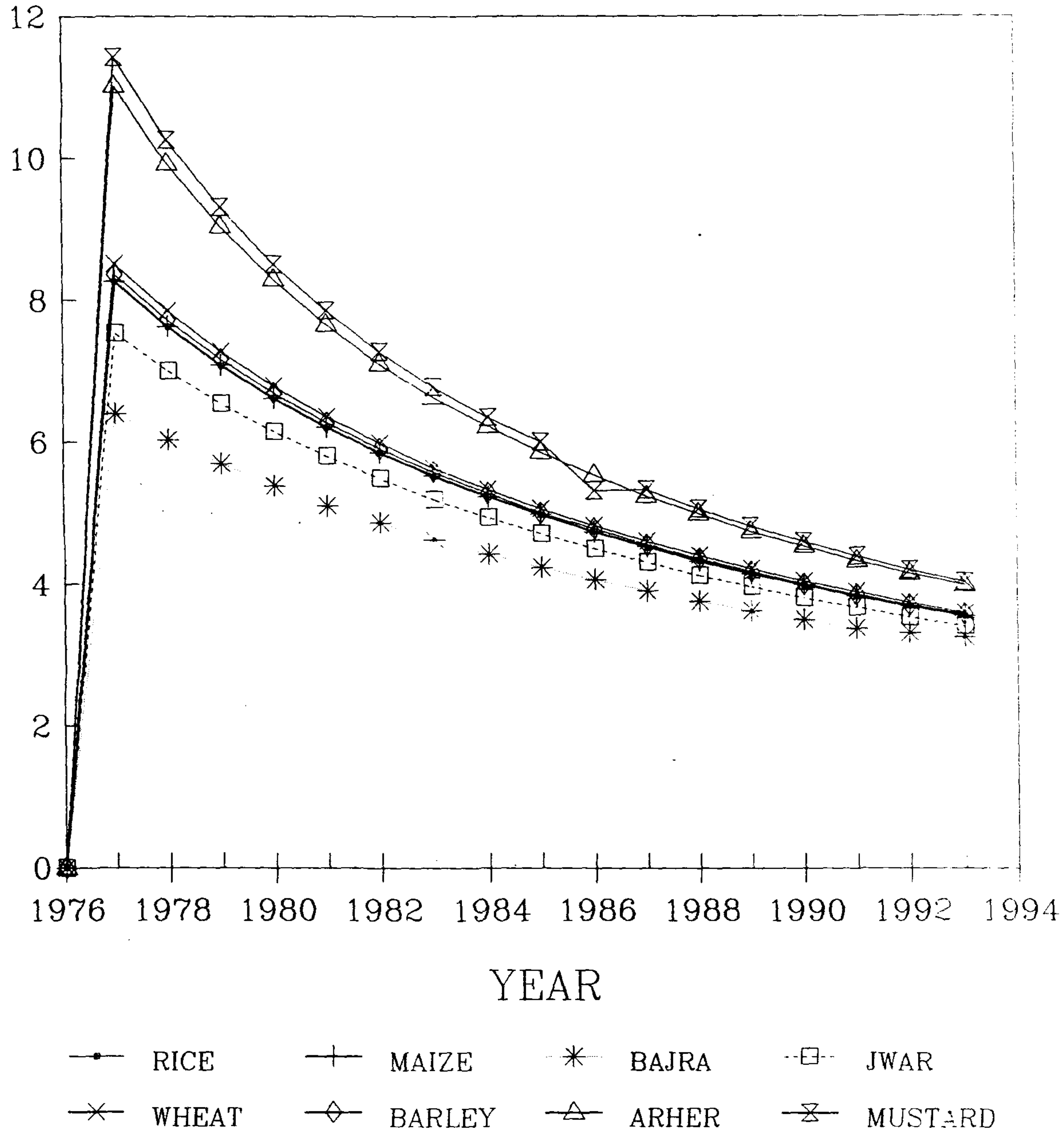


Fig. 3.10C

to latter incorporation of Ghaziabad district in the region, the analysis of the region begins from 1977 to 1993. The percentage of area under wheat shows rising trend since 1976-77 to 1981-82 since then it shows declining trend, though it has occupied the highest percentage of area among all the crops. It is followed by sugarcane, which also reveals the fluctuating trend from time to time, but it has occupied the second highest percentage of area among the selected crops. This consistent behavioral growth is not observed in case of paddy, which has shown many fluctuations. It reflects slow growth, which can be explained by the limitation, passed by the fixity of land. The area under maize reveals constantly declining trend upto 1979 and then it shows very slow growth and again trend followed the decline one. The declining trend under jwar, bajra, maize and barley clearly suggest the area shift from coarse cereal to mainly wheat, paddy and sugarcane. It is due to the new package programs widely introduced in wheat, rice and sugarcane production.

Production Variability

Table 3.11 and Figures 3.11A and B shows percentage change, simple growth and trend of production of different crops in Upper Ganga-Yamuna Doab. The analysis of the table regarding the production of selected crops reveals that the production of wheat has almost doubled from 1976-77 to 1993-94 which registered the growth of 177 percent. The trend of the production increased from 1976-77 to 1981-82 and then it declined and again starts to increase upto 1987. The production of rice has increased 156.29 percent from 1976-77 to 1993-94. The trend of rice is rather very fluctuating as compared to wheat. The temporal variation is almost similar for both wheat and paddy as evident from the table. The

TABLE 3.11

UPPER GANGA YAMUNA DOAB

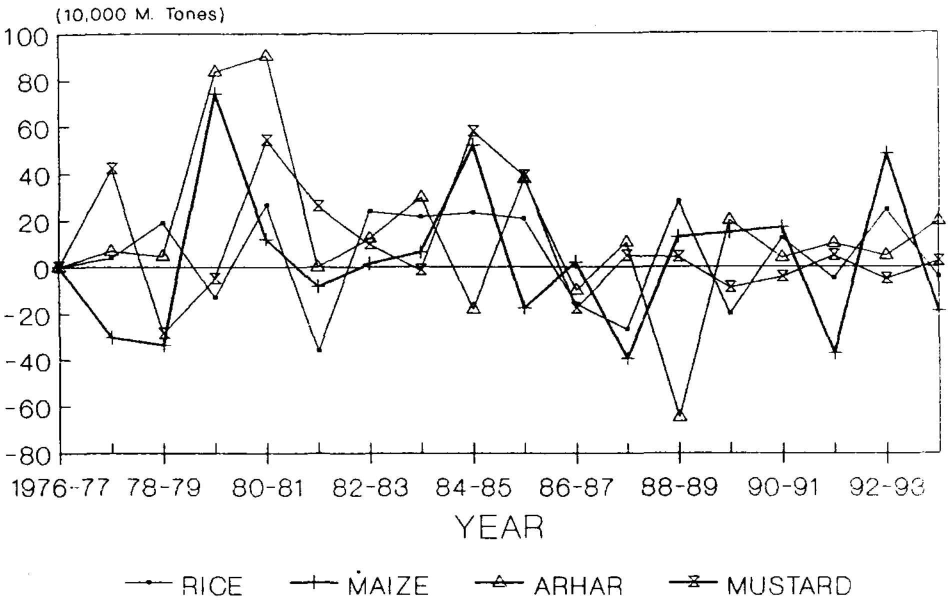
%AGE CHANGE OF PRODUCTION AND TREND OF SELECTED CROPS (1976-1994)

YEAR	RICE				MAIZE				BAJRA				JWAR				WHEAT			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
1976-77	222543	0.00	0.00	29.76	242075	0.00	0.00	31.96	22912	0.00	0.00	3.05	1446	0.00	0.00	0.23	1351603	0.00	0.00	199.91
1977-78	230978	3.79	9.17	32.49	168818	-30.26	9.15	34.89	20427	-10.85	7.92	3.22	1701	17.63	10.29	0.25	1356772	0.38	9.31	218.52
1978-79	275087	19.10	8.40	35.21	112194	-33.54	8.38	37.81	6295	-69.18	10.61	3.59	156	-90.83	9.33	0.28	1385223	16.84	8.51	237.13
1979-80	238705	-13.23	7.75	37.94	307897	74.43	7.73	40.74	11572	83.83	7.07	3.87	1192	64.10	8.53	0.30	1333683	3.06	7.85	255.73
1980-81	302609	26.77	7.19	40.67	344540	11.90	7.18	43.66	32105	97.43	6.60	4.14	1002	-15.94	7.86	0.32	1901031	16.36	7.27	274.34
1981-82	133688	-35.99	6.71	45.60	315468	-8.44	6.70	46.59	37995	18.35	6.20	4.42	300	-70.06	7.29	0.35	1817648	-4.39	6.78	292.94
1982-83	239729	23.77	6.29	47.13	319664	1.33	6.28	49.51	48150	26.73	5.83	4.69	3131	115.66	6.79	0.37	1919234	5.59	6.35	311.55
1983-84	291542	21.61	5.92	48.86	340207	6.43	5.91	52.44	46764	-2.88	5.51	4.96	1558	-50.24	6.36	0.40	2054861	7.07	5.97	330.16
1984-85	359969	23.47	5.59	51.59	517623	52.15	5.58	55.36	44239	-5.40	5.22	5.24	5885	97.73	5.98	0.42	2068753	0.68	5.64	348.76
1985-86	455419	20.96	5.29	54.31	426555	-17.59	5.28	58.28	26338	-40.46	4.97	5.51	1688	-71.32	5.64	0.44	2478033	19.78	5.33	367.37
1986-87	366686	-15.79	5.02	57.04	434368	1.83	5.02	61.21	48431	83.88	4.73	5.78	1969	16.65	5.34	0.47	2156886	-12.96	5.06	385.98
1987-88	268171	-26.87	4.78	59.77	263698	-39.29	4.78	64.13	22834	-62.85	4.52	6.06	1963	-0.30	5.07	0.49	2101374	-2.57	4.82	404.58
1988-89	343551	28.11	4.57	62.50	297390	12.73	4.56	67.06	47320	77.23	4.32	6.33	4995	95.45	4.82	0.51	2450746	16.63	4.60	423.19
1989-90	274914	-19.98	4.37	65.22	341180	14.73	4.36	69.98	21903	-53.71	4.14	6.60	2137	-57.22	4.60	0.54	2210318	-9.81	4.40	439.80
1990-91	308302	12.15	4.18	67.96	399311	17.04	4.18	72.91	35705	63.01	3.98	6.88	3025	41.55	4.40	0.56	2144471	-2.98	4.21	460.40
1991-92	292538	-5.11	4.02	70.69	250813	-37.19	4.01	75.83	26856	-24.78	3.82	7.21	2412	-20.26	4.22	0.58	2050331	-4.39	4.04	479.01
1992-93	363908	24.40	3.86	73.42	371335	48.06	3.86	78.76	28708	6.90	3.68	7.42	4769	80.72	4.05	0.61	2311139	12.72	3.88	497.61
1993-94	347824	-4.42	3.72	76.14	300463	-19.09	3.71	81.68	19923	-30.61	3.29	7.70	2462	-43.52	3.89	0.63	2392239	3.51	3.74	516.22

YEAR	BARLEY				POTATO				SUGARCANE				ARHAR				MUSTARD			
1976-77	47818	0.00	0.00	5.99	166532	0.00	0.00	46.08	25501120	0.00	0.00	3044.27	5254	0.00	0.00	0.94	1321	0.00	0.00	1.76
1977-78	39500	-16.70	10.38	6.62	231238	38.86	9.85	50.62	30680012	21.31	1.32	3084.39	4615	-12.16	10.75	1.05	2003	51.63	12.14	1.97
1978-79	36858	-6.69	9.41	7.24	344703	49.07	8.97	55.16	23357956	-23.87	1.30	3124.52	1229	-73.37	9.71	1.15	1692	-15.53	10.82	2.18
1979-80	31042	-15.78	8.60	7.87	371386	7.74	8.23	59.70	22153576	-5.16	1.28	3164.65	2887	84.91	8.85	1.25	1188	-29.79	9.77	2.40
1980-81	45610	46.93	7.92	8.49	339212	-8.66	7.60	64.24	25322200	14.30	1.27	3204.77	4197	45.38	8.13	1.35	4695	95.20	8.90	2.61
1981-82	37237	-18.36	7.34	9.11	447731	31.99	7.07	68.78	29254694	15.53	1.25	3244.90	6918	64.83	7.52	1.46	6960	48.24	8.17	2.82
1982-83	37047	-0.52	6.83	9.74	385677	-13.86	6.60	73.25	31060946	6.17	1.24	3285.03	6597	-4.64	6.99	1.56	6062	-12.90	7.55	3.04
1983-84	37539	1.34	6.40	10.36	531693	37.86	6.19	77.86	31807128	2.40	1.22	3325.16	10618	60.95	6.54	1.66	8375	38.16	7.02	3.25
1984-85	42552	13.35	6.01	10.98	541186	1.79	5.83	82.39	24456940	-23.11	1.21	3365.28	11914	12.21	6.13	1.76	24103	87.80	6.56	3.46
1985-86	61728	45.06	5.67	11.60	402041	-25.71	5.51	86.39	27524998	12.54	1.19	3405.41	13572	13.92	5.78	1.86	26558	10.19	6.16	3.68
1986-87	59795	-3.13	5.37	12.23	555568	38.19	5.22	91.47	31119788	13.06	1.18	3445.54	11256	-17.06	5.46	1.97	21685	-18.35	5.80	3.89
1987-88	63799	6.70	5.09	12.85	598079	7.65	4.96	96.01	34354168	10.39	1.16	3485.67	13552	20.14	5.18	2.07	21440	-1.13	5.48	4.10
1988-89	89797	40.75	4.85	13.47	551834	-7.73	4.73	100.55	32765480	-4.62	1.15	3525.79	3803	-71.94	4.93	2.17	32966	53.76	5.19	4.34
1989-90	76996	-14.26	4.62	14.09	514176	-6.82	4.51	105.09	33320644	1.69	1.14	3566.92	16019	95.20	4.76	2.27	29164	-11.53	4.94	4.53
1990-91	88745	15.26	4.42	14.72	555714	8.08	4.32	109.63	35643996	6.97	1.13	3606.05	13204	-17.57	4.48	2.37	32563	11.65	4.71	4.75
1991-92	94979	7.02	4.23	15.34	573471	3.20	4.14	114.17	38170504	7.09	1.11	3646.17	15330	16.10	4.29	2.47	29201	-10.32	4.50	4.96
1992-93	100507	5.82	4.06	16.00	550222	-4.05	3.98	118.71	34649680	-9.22	1.10	3686.30	12966	-15.52	4.12	2.58	32039	9.72	4.30	5.17
1993-94	88611	-11.84	3.90	16.75	563420	15.28	3.82	123.25	36823976	6.28	1.09	3726.43	16569	27.79	3.95	2.68	34405	7.38	4.13	5.38

NOTE : A = AREA, B = SIMPLE GROWTH, C = LINEAR GROWTH, D = TREND

UPPER GANGA-YAMUNA DOAB
%AGE CHANGE OF PRODUCTION OF DIFFERENT CROPS (1976-94)



UPPER GANGA-YAMUNA DOAB
%AGE CHANGE OF PRODUCTION OF DIFFERENT CROPS (1976-94)

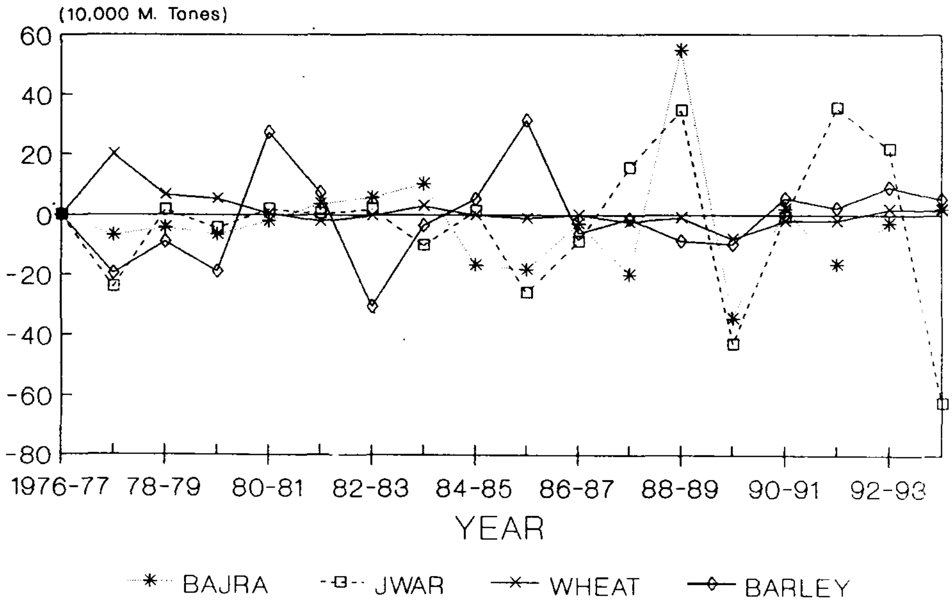


Fig. 3.11A,B

sugarcane production registered 144.40 percent growth i.e., 25501120 metric tones in 1976-77 to 36823976 metric tones in 1993-94. The production of maize increased 124 percent from 242075 metric tones in 1976-77 to 300463 metric tones in 1993-94. The tremendous increase of production of potato has been observed which registered more than 300 percent from 1976-77 to 1993-94. The marked increase of production of mustard recorded 26 times found from the base year to the current year where as arhar registered more than 3 times increase in respective year. These figures finally reveal that the output of the major crops rose due to the impact of new agricultural technology. There has been considerable variation in annual production which emphasis the importance of climatic factors as major determinants of agricultural production. In fact, annual production changes in the same direction as the winter depression untimely witnesses in the study area.

Production Trend

In order to obtain trend lines of the production of various crops for the period under review, the following equation has been used.

$$Y_c = a + bx$$

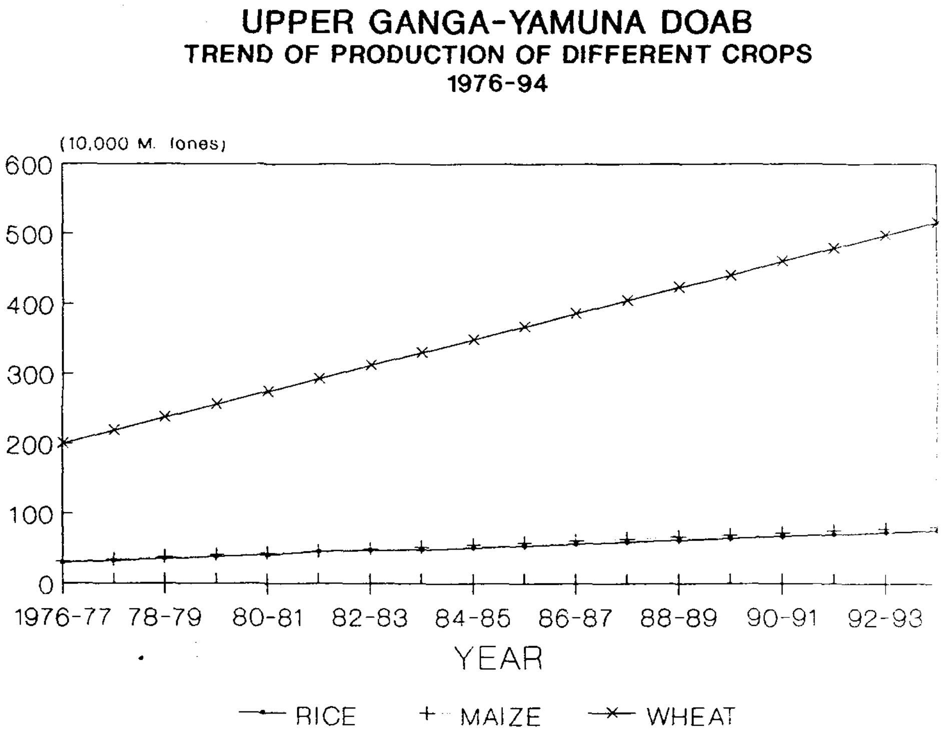
The trend as worked out with the above equation comes as follows for selected crops.

a	=	29.75	b	=	2.72	(Rice)
a	=	31.96	b	=	8.47	(Maize)
a	=	3.04	b	=	0.27	(Bajra)
a	=	0.22	b	=	0.023	(Jwar)
a	=	199.91	b	=	18.60	(Wheat)

a	=	5.99	b	=	0.62	(Barley)
a	=	46.08	b	=	4.53	(Potato)
a	=	0.94	b	=	0.10	(Arhar)
a	=	1.75	b	=	0.21	(Mustard)

These trend values have been plotted in Figures 3.11A1 and B2 show as to make an easy comparison. Figures reveal that production of wheat increased rapidly as compared to rice, which has increased moderately. The graphs plotted for barley, maize, jwar and potato, show moderate growth. The two measures used so far are the percentage change and the production trend, which provided absolute variability. In fact three years moving averages indicate more comprehensive picture, which are computed separately for area, production and yield, in terms of simple growth, linear growth and trend of selected crops. The time series graphs are plotted for area and yields. These graphs reveal that output growth is also made substantially by increase area upto certain period, and thereafter the growth of area fluctuates from time to time but the production and yield has substantially increased. The reason behind the increased productions and yield per hectare is due to intensive use of fertilizers and assured irrigation.

The coefficient of correlation worked out between area and production and area and yield of the selected crops further confirms the role of area in raising the production levels. For most of the crops such as rice, bajra, wheat, barley, potato, sugarcane, arhar and mustard while maize and jwar reveals the negative correlation. The 't test' further confirms the level of significance for all the crops except arhar. Table 3.12 shows the relation between area and production and between area and yield. The significance at 0.05 level and 0.01 calculated


UPPER GANGA-YAMUNA DOAB
TREND OF PRODUCTION OF DIFFERENT CROPS
1976-94
(10,000 M. Tones)
600
500
400
300
200
100
0
1976-77
78-79
80-81
82-83
84-85
86-87
88-89
90-91
92-93
YEAR
RICE
MAIZE
WHEAT

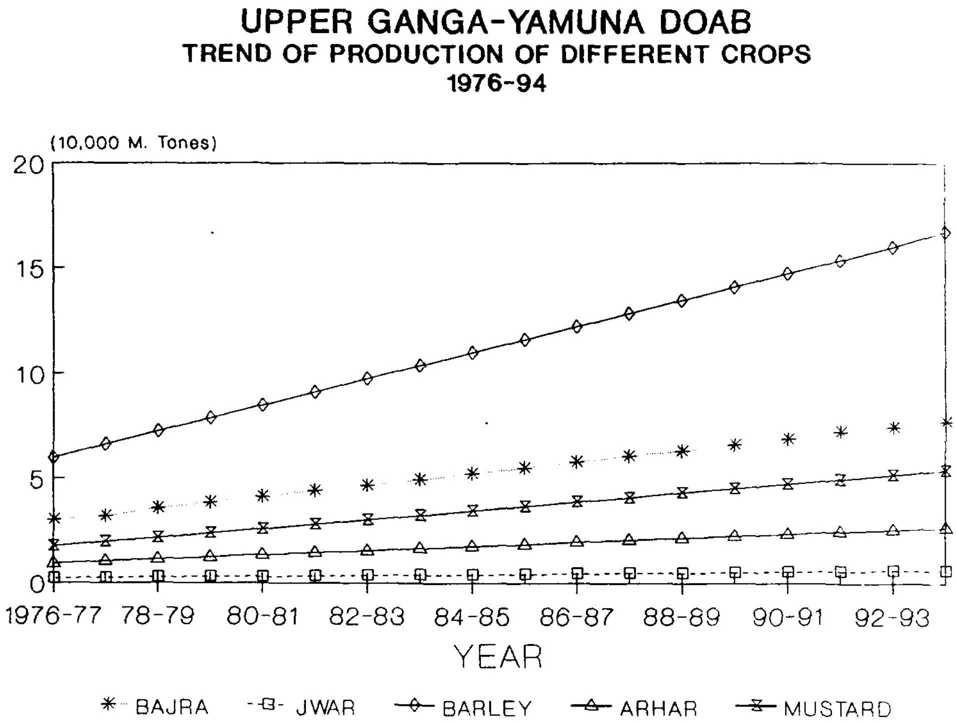

UPPER GANGA-YAMUNA DOAB
TREND OF PRODUCTION OF DIFFERENT CROPS
1976-94
(10,000 M. Tones)
20
15
10
5
0
1976-77
78-79
80-81
82-83
84-85
86-87
88-89
90-91
92-93
YEAR
BAJRA
JWAR
BARLEY
ARHAR
MUSTARD

Fig. 3.11A1,B2

TABLE 3.12

UPPER GANGA-YAMUNA DOAB

RELATIONSHIP BETWEEN AREA AND PRODUCTION

CROPS/ DISTRICT	SAHARANPUR		MUZAFFAR NAGAR		MEERUT		BULANDSHAHR		GHAZIABAD		UPPER GANGA-YAMUNA DOAB	
	Y	T	Y	T	Y	T	Y	T	Y	T	Y	T
RICE	-0.360	127.015	0.608	88.915	-0.095	36.165	0.414	13.575	0.409	26.528	0.204	207.604
MAIZE	0.719	11.413	0.968	11.399	0.861	25.769	0.313	111.312	0.261	51.527	-0.092	142.045
BAJRA	0.943	64.049	0.947	39.139	0.786	53.115	0.164	32.325	0.154	25.602	0.149	37.821
JWAR	0.883	36.084	0.904	43.966	0.928	58.498	0.619	87.582	-0.701	21.468	-0.124	43.618
WHEAT	0.161	225.681	-0.068	285.575	-0.429	308.480	0.719	378.192	-0.362	274.571	0.245	747.472
BARLEY	0.903	3.792	0.683	10.50	0.951	6.319	0.086	86.003	-0.295	32.520	0.093	106.152
POTATO	0.841	7.816	0.784	54.186	0.883	177.368	0.960	155.773	0.957	319.016	0.901	640.114
SUGARCANE	0.545	2300.344	0.951	2929.094	0.876	2710.275	0.562	1477.181	0.772	1579.537	0.629	5544.27
ARHAR	0.554	12.548	0.986	15.913	0.360	41.601	0.920	11.338	0.986	1.366	0.922	1.038
MUSTARD	0.843	342.706	0.976	446.573	0.975	451.70	0.969	218.363	0.972	6.296	0.945	23.216

RELATIONSHIP BETWEEN AREA AND YIELD

RICE	-0.686	314.769	0.130	204.226	-0.768	120.416	-0.319	94.442	0.096	97.909	-0.400	415.637
MAIZE	-0.015	140.086	-0.332	81.026	-0.605	134.916	-0.066	368.28552	-0.485	197.617	-0.627	481.088
BAJRA	-0.611	28.586	-0.114	15.383	-0.680	41.330	-0.524	139.19096	-0.898	116.141	-0.513	204.552
JWAR	0.422	15.584	-0.423	6.476	-0.263	15.427	-0.452	49.76426	-0.835	39.098	-0.549	81.429
WHEAT	-0.363	433.939	-0.261	441.566	-0.802	413.530	0.631	510.66666	-0.548	339.200	-0.204	925.158
BARLEY	-0.845	20.108	0.269	15.182	-0.515	19.899	-0.338	149.89729	-0.494	60.108	-0.170	174.335
POTATO	0.546	26.459	0.412	35.868	-0.609	67.928	0.860	72.94389	0.837	71.042	0.669	151.188
SUGARCANE	-0.424	327.407	0.850	433.717	0.737	437.829	-0.326	234.19083	0.649	230.090	0.343	780.560
ARHAR	-0.468	9.060	-0.652	9.424	-0.560	19.213	-0.667	43.06826	-0.205	29.709	-0.354	91.769
MUSTARD	0.153	27.817	0.890	25.814	0.855	26.654	0.801	54.85569	0.755	47.900	0.720	139.081

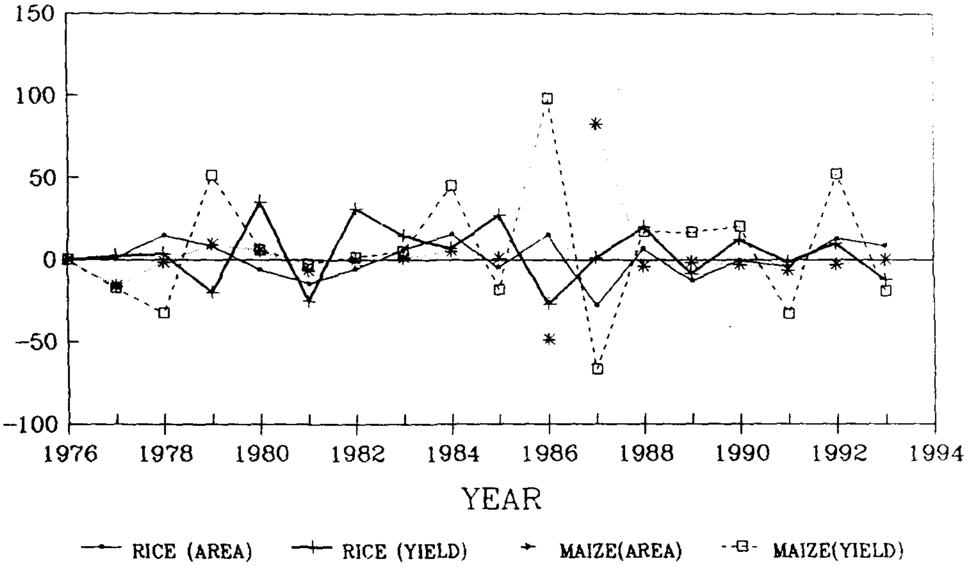
Note : Y = Correlation, T = T-values

values of all the crops are greater than that of table values at that particular level of significance except arhar in case of area and production. But in case of area and yield it has greater value than that of the level of significance. Whereas the relationship between area and yield of all the crops show negative coefficient of correlation. In case of rice, maize, jwar, bajra, wheat, barley and arhar. Whereas potato, sugarcane, and mustard shows positive correlation between area and yield. It means the area is steadily decreasing and yield is continuously increasing (Figures 3.12 A, A1 and B, B1). The reason behind the negative correlation between area and yield of the above said crops due to the acceptance of new packages of the programme by the farmers and availability of assured irrigation as well as the applications of high doses of fertilizer. Besides the changing cropping pattern is one of the major causative factor for the decreasing of area under the above crops because the farmers are paying their attention towards more remunerative crops i.e., horticulture, vegetables and cash crops.

Tables 3.13A and B exhibit the percentage change of production, linear growth and trend of different district of the study area. Table 3.12 also reveals the relation between area and production as well as relation between area and yield of different districts of Upper Ganga-Yamuna Doab.

In Saharanpur district the output of wheat increased 1.45 times from 240289 tones in 1970-73 to 348235 tones in the year 1991-94. The output of the rice increased 1.69 times from 1970-73 to 1991-94. Whereas potato increased 3.85 times from the 1970-73 to 1991-94. Production of jwar increased 4.78 times from 1970-73 to 1991-94. Muzaffarnagar district shows spectacular increase of barley and potato as well as mustard

UPPER GANGA YAMUNA DOAB
RELATIONSHIP BETWEEN AREA AND YIELD
(1976-94)



UPPER GANGA YAMUNA DOAB
RELATIONSHIP BETWEEN AREA AND YIELD
(1976-94)

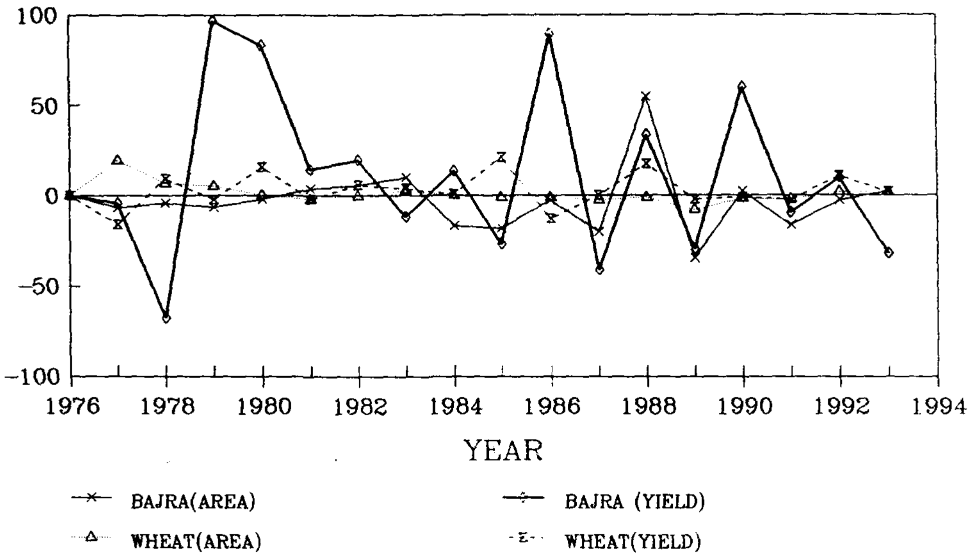
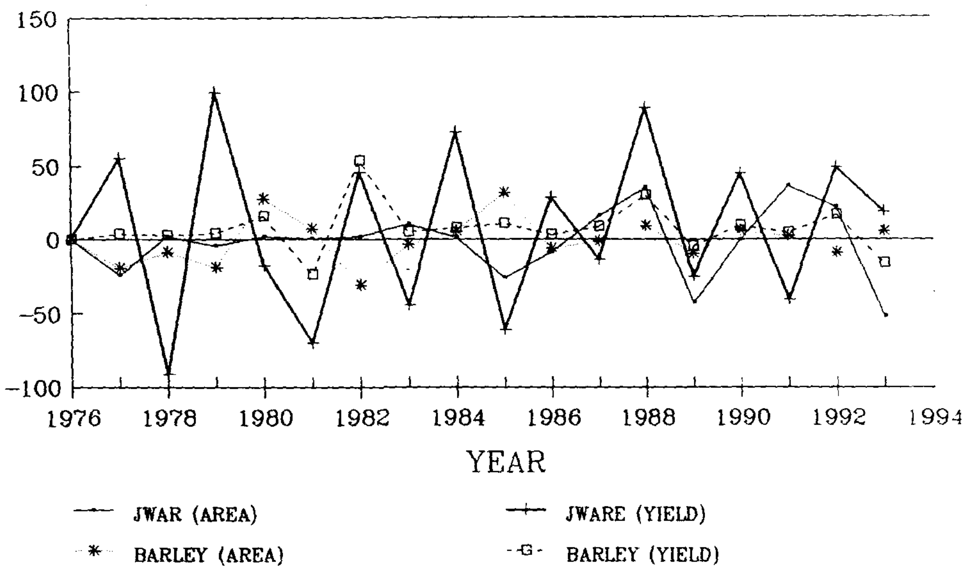


Fig. 3.12A,A1

UPPER GANGA-YAMUNA DOAB
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94



UPPER GANGA-YAMUNA DOAB
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94

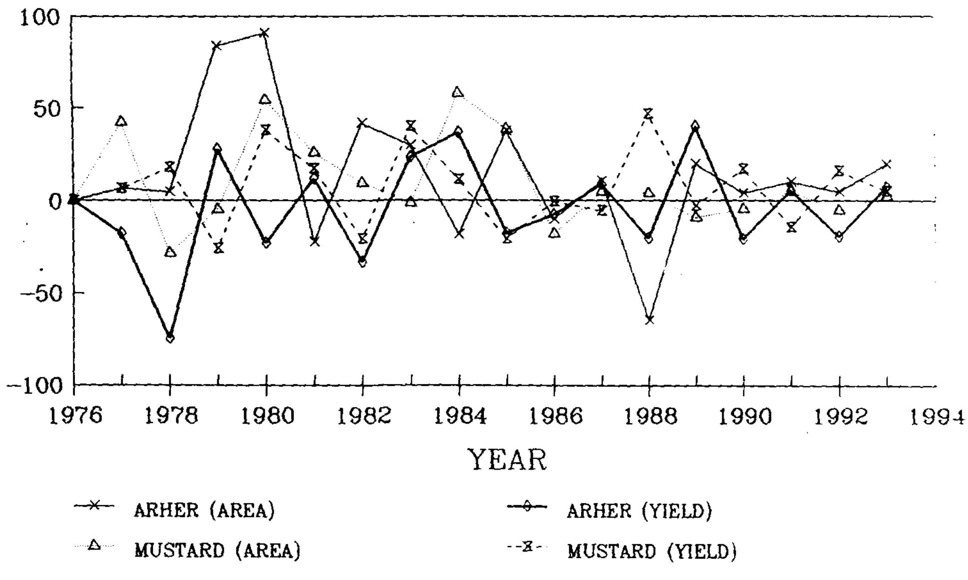


Fig. 3.12B,B1

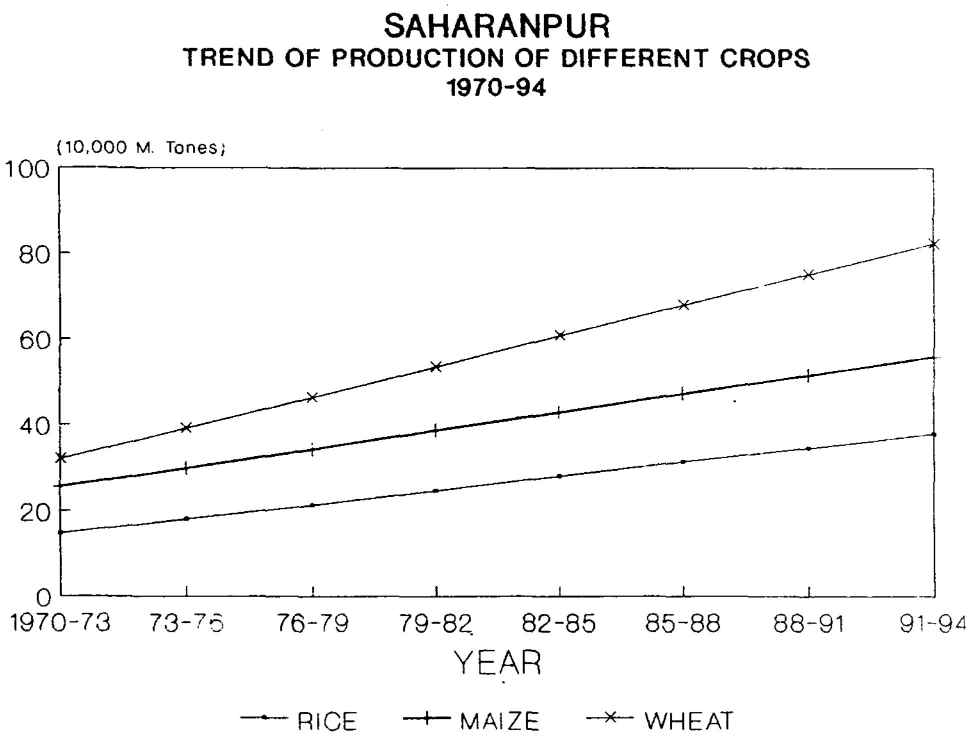
while wheat, rice, maize, bajra and jwar has not increased as much as the potato, barley and mustard. The highest increase in terms of production is found in mustard followed by barley and potato i.e., 23.34 times, 7.74 times and 6.85 times respectively from 1970-73 to 1991-94. The district Meerut and Bulandshahr show almost the same patterns in terms of production of selected crop. Both the districts reveal the highest growth in mustard and potato from 1970-73 to 1991-94. The district Ghaziabad shows the highest growth of mustard among all the districts i.e., 53.12 times from 1971-73 to 1991-94. Besides, it also exhibited the highest growth rate in wheat and rice among the entire district.

PRODUCTION TREND OF THE DISTRICTS OF UPPER GANGA-YAMUNA DOAB

In order to obtain trend lines of the production of selected crops of the period under review, the same equation has been used which has been employed for the analysis of the region i.e., $$Yc = a + bx$$

The trend values of Saharanpur district has been plotted in Figures 3.13A and B and shown a to make as easy comparison. The above figure suggests that production of wheat increased rapidly as compared to rice, maize, bajra and jwar etc. The trend of rice has increased moderately, on the other hand the trend of bajra, jwar, barley, mustard, and arhar show declining trend as compared to food grains. The coefficient of correlation worked out between area and production, and between area and yield further confirms the contribution of area in raising the production level except in the case of rice. The other crops have very good relationship but is very in significant as compare to barley and potato, sugarcane and mustard. The coefficient of correlation between area and yield show negative relation except two crops jwar and bajra. It confirms that inspite of increasing the area under the different crops the volume of production is increasing, it means the yield per hectare is increasing because of the availability of assured irrigation, application of chemical fertilizer and control of insects and pest through the use of insecticide, pesticide and other chemicals.

Table 3.13A and B show the percentage change of production, linear growth and trend of selected crops. Figures 3.14 A and B reveals the trend line of the different crops, the trend has worked out with the same equation. In the case of


SAHARANPUR
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
100
80
60
40
20
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
WHEAT

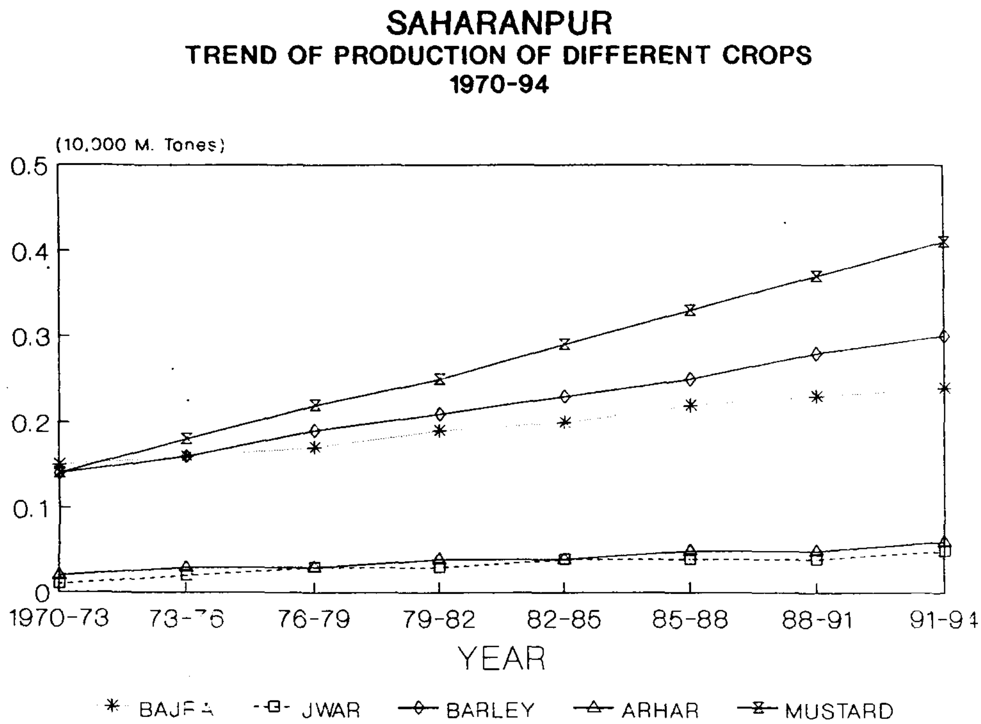
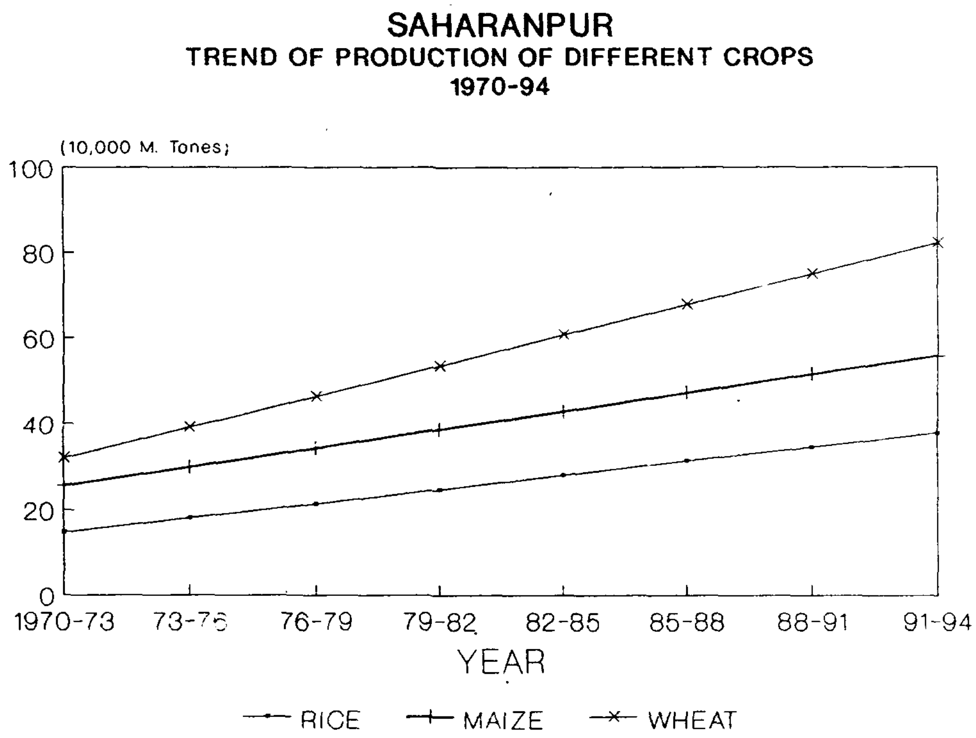

SAHARANPUR
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
0.5
0.4
0.3
0.2
0.1
0
1970-73
76-79
79-82
82-85
85-88
88-91
YEAR
JWAR
BARLEY
ARHAR
MUSTARD

Fig. 3.13A,B


SAHARANPUR
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
100
80
60
40
20
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
WHEAT

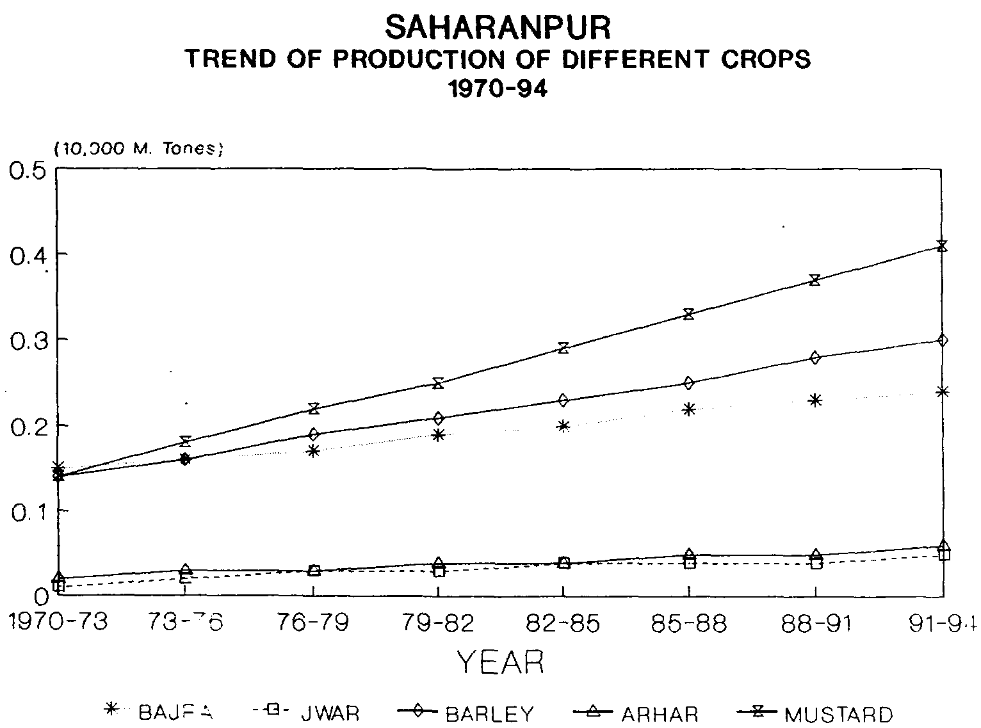

SAHARANPUR
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
0.5
0.4
0.3
0.2
0.1
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA
JWAR
BARLEY
ARHAR
MUSTARD

Fig. 3.13A,B

TABLE 3.13A

UPPER GANGA-YAMUNA DOAB

%AGE CHANGE OF PRODUCTION AND TREND OF SELECTED CROPS (1970-1994)

YEAR	RICE				MAIZE				BAJRA				JWAR				WHEAT			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
									SAHARANPUR											
1970-73	97253	0.00	0.00	14.78	34629	0.00	0.00	25.51	5388	0.00	0.00	0.15	81	0.00	0.00	0.01	240289	0.00	0.00	31.94
1973-76	101152	4.00	22.36	18.08	24589	-28.99	17.08	29.87	1735	87.80	9.64	0.16	70	-13.52	27.38	0.02	162413	-32.41	22.57	39.14
1976-79	143682	42.05	18.27	21.39	25583	4.05	14.58	34.23	1335	-23.20	8.79	0.17	36	-49.29	21.50	0.03	283896	74.80	18.41	46.35
1979-82	141643	-1.42	15.45	24.69	27811	8.71	12.73	38.58	695	-47.82	8.08	0.19	23	-35.51	17.70	0.03	314274	10.70	15.55	53.56
1982-85	170807	71.30	13.38	27.99	37442	34.63	11.29	42.94	669	-3.74	7.47	0.20	386	78.26	15.03	0.04	411741	31.01	13.46	60.77
1985-88	199036	16.85	11.80	31.30	29772	-20.49	10.15	57.30	792	18.28	6.96	0.22	149	-61.31	13.07	0.04	431488	4.80	11.86	67.97
1988-91	163470	-17.87	10.56	34.60	17913	-39.83	9.21	51.65	732	-7.54	6.50	0.23	173	15.85	11.56	0.04	362545	-15.98	10.60	75.18
1991-94	164128	0.40	9.55	37.91	6374	-64.42	8.43	56.01	305	-58.33	6.10	0.24	387	80.89	10.36	0.05	348235	-3.95	9.59	82.39
									MUZAFFAR NAGAR											
1970-73	46231	0.00	0.00	7.24	54796	0.00	0.00	2.02	3963	0.00	0.00	0.07	136	0.00	0.00	0.01	267191	0.00	0.00	34.92
1973-76	39654	-14.23	23.83	8.6	22675	-58.62	13.30	2.29	778	-80.36	5.95	0.08	44	-67.57	12.62	0.01	228281	-14.56	22.76	42.87
1976-79	56354	41.68	19.24	10.69	13086	-42.29	11.74	25.56	341	-66.15	5.61	0.09	12	-71.97	11.21	0.01	270912	18.67	18.54	50.82
1979-82	63595	13.24	16.13	12.41	17697	35.24	10.50	28.24	321	-5.96	5.31	0.09	14	10.82	10.08	0.02	365311	34.85	15.64	58.76
1982-85	80580	26.72	13.89	14.14	18881	6.69	9.50	34.93	276	-14.12	5.05	0.10	65	78.03	9.15	0.02	362305	-0.82	13.52	66.71
1985-88	105329	30.71	12.20	15.86	15152	-19.75	8.68	33.61	262	-4.96	4.80	0.10	38	-41.33	8.39	0.02	426640	17.76	11.91	74.66
1988-91	90611	13.97	10.87	17.59	22081	-20.26	7.99	36.30	101	-61.58	4.58	0.11	26	-32.17	7.74	0.02	435527	2.08	10.64	82.61
1991-94	97015	7.07	9.81	19.31	7162	-40.72	7.40	38.98	142	41.06	4.38	0.12	04	-85.90	7.18	0.02	437716	0.50	9.62	90.55
									MEERUT											
1970-73	28758	0.00	0.00	2.59	82983	0.00	0.00	4.68	6514	0.00	0.00	0.26	1136	0.00	0.00	0.03	374980	0.00	0.00	40.46
1973-76	23602	-17.93	21.25	3.14	63937	-22.95	16.47	5.45	2974	-54.35	14.15	0.29	476	-5.23	9.98	0.03	349013	-6.92	21.54	49.17
1976-79	17627	-25.31	17.53	3.68	24219	-65.12	14.14	6.22	1022	-65.64	12.40	0.33	72	-84.89	9.07	0.04	303938	-12.92	17.72	57.87
1979-82	22191	25.89	14.91	4.24	46482	91.93	12.39	6.99	2143	49.15	11.03	0.36	50	-30.23	8.32	0.04	374048	23.07	15.05	66.60
1982-85	25320	14.10	12.98	4.79	51227	10.21	11.02	7.76	3624	69.15	9.94	0.40	373	74.66	7.68	0.04	421363	12.65	13.08	73.30
1985-88	28394	12.14	11.48	5.34	37890	-26.03	9.93	8.53	1685	-35.51	9.04	0.44	135	-60.07	7.13	0.05	481815	14.35	11.57	84.03
1988-91	26481	-6.74	10.30	5.89	39395	3.97	9.03	9.30	1095	-35.00	8.29	0.47	102	-24.26	6.66	0.05	494812	2.68	10.37	92.74
1991-94	34600	30.66	9.34	6.44	27979	-28.98	8.28	10.07	1387	26.68	7.66	0.51	118	15.68	6.24	0.06	436728	-11.72	9.40	101.45
									BULANDSHAHR											
1970-73	8560	0.00	0.00	1.18	162355	0.00	0.00	18.06	21448	0.00	0.00	1.83	3519	0.00	0.00	0.17	430884	0.00	0.00	52.11
1973-76	9630	12.50	21.45	1.43	129082	-20.49	22.84	22.18	15347	-28.41	21.02	2.22	1921	-45.41	18.44	0.21	319648	25.82	23.05	64.13
1976-79	15286	58.74	17.66	1.68	76143	-41.01	18.59	26.31	7763	-49.42	17.37	2.60	791	-58.82	15.57	0.24	383607	20.01	18.74	76.14
1979-82	13472	-11.87	15.01	1.93	169003	51.95	15.68	30.43	13103	68.78	14.80	2.99	531	-32.91	13.47	0.27	488681	27.39	15.78	88.16
1982-85	7809	-42.03	13.05	2.19	222492	31.65	13.35	34.56	29992	108.90	12.79	3.37	2039	88.23	13.87	0.30	549477	12.44	13.63	100.78
1985-88	10606	35.81	11.54	2.44	237746	6.86	11.94	38.68	20035	-33.20	11.42	3.76	1112	-45.48	10.61	0.34	618681	12.59	11.99	112.19
1988-91	12718	19.91	10.35	2.69	227533	-4.30	10.66	42.81	23481	17.20	10.25	4.14	2189	96.91	9.57	0.37	670599	8.39	10.71	124.20
1991-94	16003	25.83	9.38	2.94	220361	-3.15	9.64	46.93	15459	-34.17	9.30	4.53	1882	-14.04	8.75	0.40	707567	5.51	9.67	136.22
									GHAZIABAD											
1976-79	10119	0.00	0.00	1.30	35331	0.00	0.00	5.14	6086	0.00	0.00	0.93	190	0.00	0.00	0.05	188846	0.00	0.00	26.88
1979-82	4104	-59.44	34.34	1.74	61641	74.47	27.37	6.55	10962	80.12	27.53	1.19	214	12.43	34.78	0.07	241802	28.04	30.21	35.00
1982-85	11563	91.74	25.56	2.19	62457	1.32	21.49	7.96	11823	7.85	21.59	1.45	697	55.70	25.78	0.09	269397	11.41	23.20	43.12
1985-88	13394	15.84	20.36	2.63	54314	-13.04	17.69	9.36	9761	-17.44	17.76	1.71	439	-36.97	20.49	0.11	286807	6.46	18.83	51.25
1988-91	15642	16.79	16.92	3.0	49031	-19.73	15.03	10.77	9567	-1.99	15.08	1.96	896	38.87	17.01	0.12	305130	6.39	15.85	59.37
1991-94	23010	43.10	14.46	3.52	45667	-6.86	13.07	12.18	7869	-17.75	13.10	2.22	687	-23.30	14.54	0.14	320990	5.20	13.68	67.49

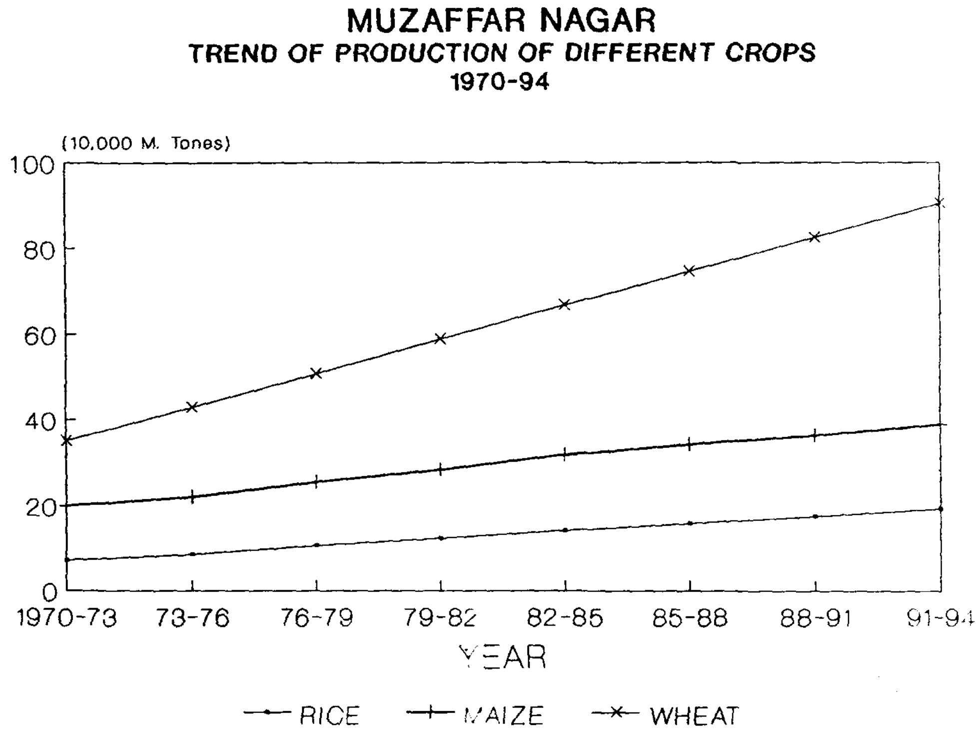
TABLE 3.13B

UPPER GANGA-YAMUNA DOAB

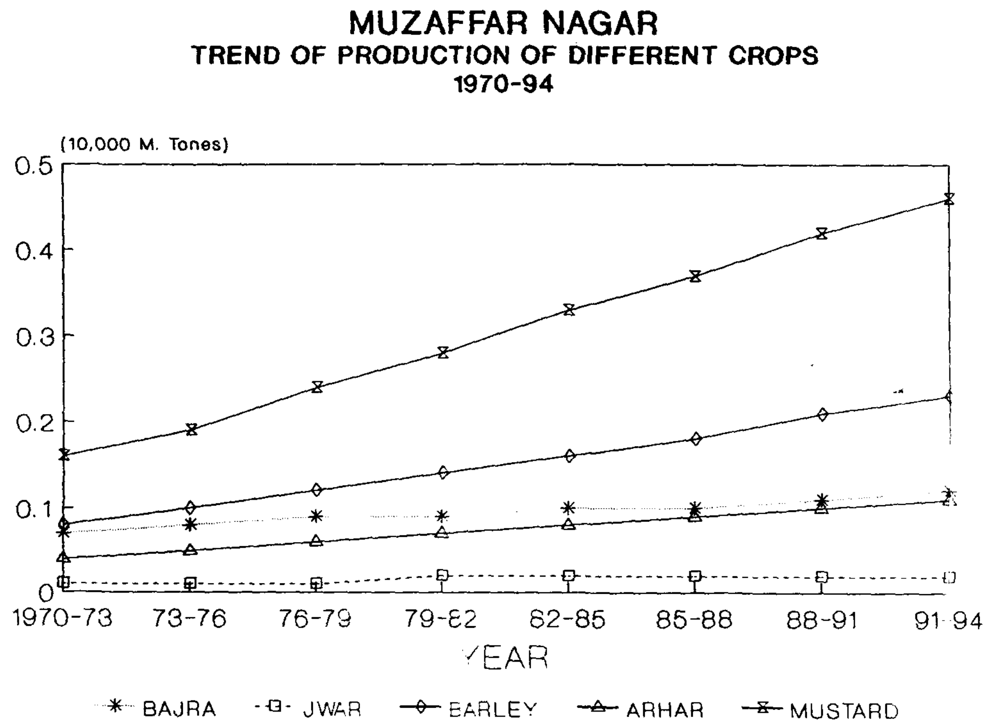
%AGE CHANGE OF PRODUCTION AND TREND OF SELECTED CROPS (1970-1994)

YEAR	BARLEY				POTATO				SUGARCANE				ARHAR				MUSTARD			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
SAHARANPUR																				
1970-73	1466	0.00	0.00	0.14	6735	0.00	0.00	22.82	4047709	0.00	0.00	596.92	318	0.00	0.00	0.02	337	0.00	0.00	0.14
1973-76	2680	82.83	16.02	0.16	14195	110.83	23.76	28.23	5190661	28.24	22.27	729.88	210	-33.99	17.58	0.03	640	89.82	27.77	0.18
1976-79	1724	-35.65	13.81	0.19	18919	33.28	19.19	33.65	5718254	10.16	18.12	862.84	337	60.73	14.95	0.03	339	-47.06	21.74	0.22
1979-82	2229	-28.75	12.13	0.21	24264	28.25	16.10	39.07	5555688	-2.84	15.41	959.81	177	-47.38	13.01	0.04	592	104.23	17.86	0.25
1982-85	2277	3.91	10.82	0.23	34893	43.81	13.87	44.38	4997549	-10.05	13.35	1128.77	338	90.60	11.51	0.04	1922	177.66	15.15	0.29
1985-88	1204	-5.72	9.76	0.25	33027	-5.35	12.18	49.90	7681340	53.70	11.78	1261.75	347	0.79	10.32	0.05	2358	22.68	13.15	0.33
1988-91	1011	16.01	8.90	0.28	24553	-25.66	10.86	55.32	7479000	-2.63	10.54	1394.70	186	-45.50	9.36	0.05	2474	4.92	11.63	0.37
1991-94	639	-36.83	8.17	0.30	25940	5.65	9.79	8.74	7083252	-5.29	9.53	1527.66	69	-63.02	8.56	0.06	573	-8.12	10.42	0.41
MUZAFFAR NAGAR																				
1970-73	295	0.00	0.00	0.08	10895	0.00	0.00	4.24	6534006	0.00	0.00	954.79	164	0.00	0.00	0.04	154	0.00	0.00	0.16
1973-76	644	117.95	28.05	0.10	35011	61.36	25.68	5.33	7353580	12.54	5.82	1172.67	111	-32.32	24.70	0.05	391	73.13	30.94	0.19
1976-79	377	-41.38	21.90	0.12	22746	-35.03	20.43	6.42	8435039	14.71	18.58	1390.55	160	47.84	19.81	0.06	299	-23.46	23.63	0.24
1979-82	343	-9.01	17.96	0.14	36223	59.25	16.97	7.51	8409524	-0.30	15.67	608.43	184	15.03	16.53	0.07	623	108.25	9.11	0.28
1982-85	433	26.02	15.23	0.16	46340	27.93	14.51	8.60	10447007	24.23	13.55	1826.31	949	76.52	14.93	0.08	1218	95.61	16.05	0.33
1985-88	589	36.21	13.22	0.18	53300	15.02	12.67	9.69	10460283	0.13	11.93	2044.19	540	-43.08	12.42	0.09	2091	71.70	13.83	0.37
1988-91	1163	97.40	11.63	0.21	60352	13.23	11.27	10.78	11719992	12.04	10.66	2262.06	565	4.57	11.05	0.10	3225	54.21	12.15	0.42
1991-94	2282	96.13	10.45	0.23	74670	23.72	10.11	11.87	13024029	11.30	9.63	2479.94	251	-55.61	9.95	0.11	3640	12.88	10.83	0.46
MEERUT																				
1970-73	4382	0.00	0.00	0.22	56537	0.00	00.00	11.24	6742290	0.00	0.00	814.71	2176	0.00	0.00	0.11	185	0.00	0.00	0.19
1973-76	5335	21.75	14.75	0.25	48703	-13.86	26.03	14.17	7921317	17.48	21.56	990.34	1455	-33.14	18.92	0.14	359	93.71	31.97	0.25
1976-79	1013	-81.02	12.86	0.28	57833	18.75	20.65	17.10	7346988	-7.25	17.75	1165.97	221	-84.78	15.91	0.16	183	-48.93	24.23	0.31
1979-82	648	-36.05	11.39	0.32	103621	79.17	17.12	20.02	7275741	-0.97	15.06	1341.60	300	35.48	13.72	0.18	400	26.36	19.50	0.37
1982-85	1036	59.91	10.23	0.35	113523	9.56	14.62	22.95	8174028	12.35	13.09	1517.22	1425	75.52	12.07	0.20	1631	67.33	16.32	0.43
1985-88	1089	5.18	9.28	0.38	148866	31.13	12.75	25.88	7902687	-3.32	11.58	1692.85	107	-23.74	10.77	0.22	3153	93.37	14.30	0.50
1988-91	1477	35.56	8.49	0.41	169226	13.68	11.31	28.80	9466997	19.79	10.37	1868.48	1018	-6.35	9.72	0.24	4246	34.66	12.30	0.56
1991-94	2469	67.18	7.86	0.44	201209	18.90	10.16	31.73	10346635	9.29	9.40	2044.11	1457	43.20	8.86	0.27	5080	19.62	10.96	0.62
BULANDSHAHR																				
1970-73	33710	0.00	0.00	4.80	40334	0.00	0.00	11.50	1665609	0.00	0.00	244.86	6231	0.00	0.00	0.50	733	0.00	0.00	0.75
1973-76	50830	50.79	23.53	5.93	54858	36.01	24.16	14.28	2239376	34.45	21.06	296.45	3268	-47.57	23.87	0.72	1708	93.02	31.18	0.99
1976-79	33558	33.98	19.05	7.06	91172	66.20	19.46	17.05	2709985	21.02	17.40	347.99	2435	-25.48	19.26	0.86	772	-54.70	23.77	1.22
1979-82	31804	-5.23	16.00	8.19	134769	47.82	16.29	19.83	2707415	-0.09	14.82	399.55	3555	46.02	16.16	0.99	2349	104.19	19.21	1.46
1982-85	31702	-0.32	13.80	9.31	168116	24.74	14.00	22.61	2725361	0.66	12.91	451.12	6026	69.51	13.91	1.14	6646	98.88	16.11	1.69
1985-88	51369	62.27	12.12	10.44	152879	-9.06	12.29	25.39	2466019	-9.52	11.43	502.69	9697	60.91	12.21	1.28	13103	90.17	13.88	1.93
1988-91	72055	40.27	10.81	11.57	132879	-13.08	10.94	28.17	2345408	-4.89	10.26	554.26	4448	-54.13	10.88	1.42	18247	39.25	12.19	2.16
1991-94	78802	9.36	9.76	4.70	144784	8.96	9.86	30.94	2729590	16.38	9.30	605.82	10934	95.83	9.81	1.56	16745	-8.23	10.86	2.40
GHAZIABAD																				
1976-79	4587	0.00	0.00	0.68	56820	0.00	0.00	11.51	2302764	0.00	0.00	257.47	547	0.00	0.00	0.17	78	0.00	0.00	0.20
1979-82	3940	-14.11	33.87	0.91	87233	53.52	23.14	15.22	1628457	-29.28	30.40	335.73	452	-17.38	38.94	0.23	216	96.17	34.34	0.28
1982-85	4597	16.69	25.30	1.14	123313	43.36	24.33	18.92	2764395	69.76	23.21	413.99	972	45.20	28.03	0.30	1430	111.02	25.56	0.36
1985-88	7523	63.63	20.19	1.37	130491	5.82	19.57	22.62	2489323	-9.95	18.90	492.24	1129	16.19	21.89	0.37	2521	76.32	20.36	0.44
1988-91	9474	25.94	16.80	1.59	153565	17.68	16.37	26.32	2898643	16.44	15.90	570.50	4793	84.38	17.96	0.43	3572	33.74	16.92	0.52
1991-94	10508	10.91	14.38	1.82	139387	-9.23	14.07	30.03	3634549	16.07	13.72	648.77	2244	-53.18	15.23	0.50	4143	22.87	14.47	0.60

NOTE : A = AREA, B = SIMPLE GROWTH, C = LINEAR GROWTH, D = TREND



MUZAFFAR NAGAR
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
100
80
60
40
20
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
WHEAT

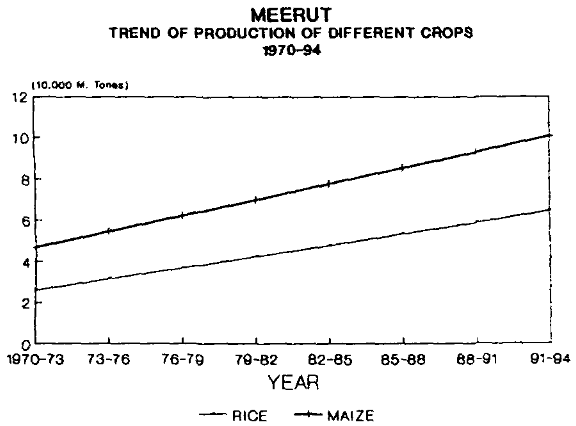


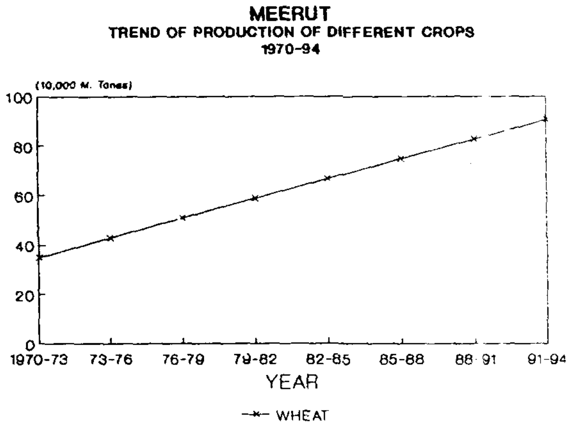
MUZAFFAR NAGAR
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
0.5
0.4
0.3
0.2
0.1
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA
JWAR
BARLEY
ARHAR
MUSTARD

Fig. 3.14A,B

Muzaffarnagar wheat production is also increasing rapidly as compared to rice, maize, bajra, jwar etc. Rice increased very moderately but it shows higher growth than that of other crops. The two measures used so for, are the percentage change and production trend, which provide absolute variability. The coefficient of correlation of area and production, and area and yield of the selected crops show the positive correlation between area and production in all the crops at different levels except wheat which show negative relationship. As for as the coefficient of correlation between area and yield is concern it shows the negative relationship in maize, bajra, jwar, wheat and arhar. The 't test' of the selected crops has been computed to examine the level of significance between area and production, and area and yield. In 8 degree of freedom at 0.05 level of significance and 0.01 level of significance the table value is 2.31 and 3.36 respectively, further confirm the significance level which is greater than the table value in case of all crops.

Table 3.13A and B reveal percentage change of production and trend of the selected crops, which show the high variability in terms of production of all the crops. Figures 3.15A, B and C show the trend lines of the selected crops, where wheat is followed by rice in mixed increasing trend but wheat is dominating here among all the crops. The coefficient of correlation between area and production, and area and yield in Meerut district as exhibited in Table 3.12, which indicates the negative relationship between area and production in case of wheat and rice but all the crops show positive relationship. The coefficients of correlation between area and yield of the selected crops in Meerut district show the negative relationship in case of all the crops except


MEERUT
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
12
10
8
6
4
2
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE


MEERUT
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
100
80
60
40
20
0
1970-73
73-76
76-79
79-82
82-85
85-88
88 91
91-94
YEAR
WHEAT

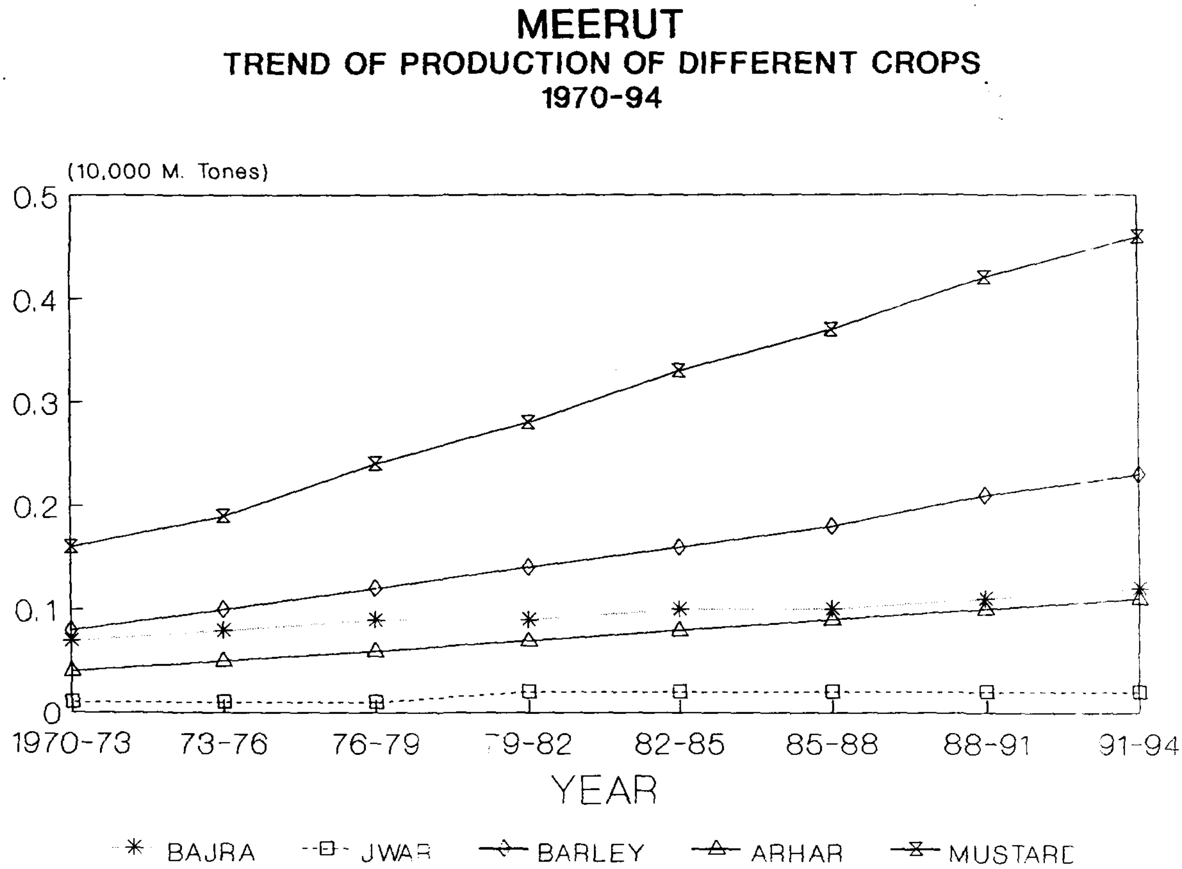
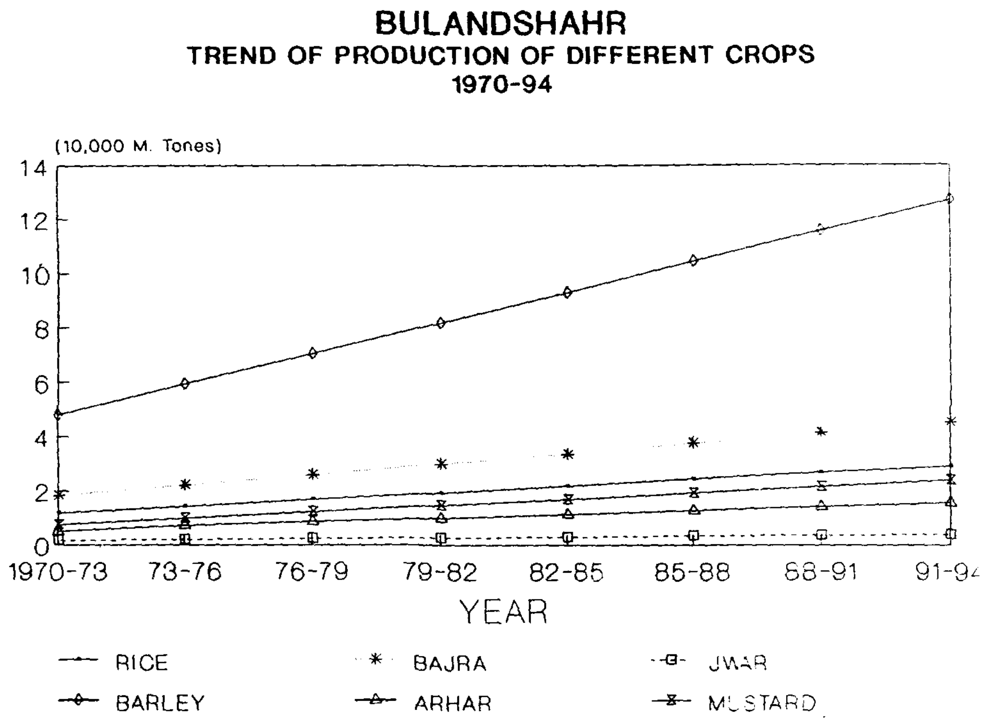

MEERUT
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
0.5
0.4
0.3
0.2
0.1
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA
JWAR
BARLEY
ARHAR
MUSTARD

Fig. 3.15A,B,C

mustard and sugarcane. It further suggests that areas is being declined and remain constant under the above crops, but the yield per hectare has rapidly increased. The reason behind the increase of yield per hectare is due to good response of the farmers towards the acceptance of diffusion of innovations, adequate supply of irrigation, availability of fertilizer and applications of the insecticides and pesticides.

Table 3.13 A and B show the percentage change of production and trend of the selected crops in Bulandshahr district. Figure 3.16A and B reveal that the trend line showing the production of selected crop give increasing trend of wheat, which is higher than that of other crops. The trend line of rice goes almost to the parallel of Ghaziabad, but it is insignificant to compare the trend lines of rice to the districts of Meerut, Muzaffarnagar and Saharanpur. Which shows the faster increasing trend than that of Bulandshahr district. Table 3.12 shows the coefficient of correlation between area and production and area and yield as well as the 't test'. In Bulandshahr district the relationship between area and production among all the crops is positive. The 't test' further confirms the level of significance at 8 degree of freedom, is higher than the table value. As far as the coefficient of correlation between area and yield is concern the negative growth among all the crops except wheat, potato and mustard. It means the yield per hectare has increased among the crops of negative relationship, but in case of wheat, mustard and potato, both the area and yield have increased.

The percentage change of production, linear growth and trend of the selected crops of Ghaziabad district is exhibited in Table 3.13 A and B and Figures 3.17A and B show the trend lines of selected crops. The table shows the high variability in


BULANDSHAHR
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
14
12
10
8
6
4
2
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
BAJRA
JWAR
BARLEY
ARHAR
MUSTARD

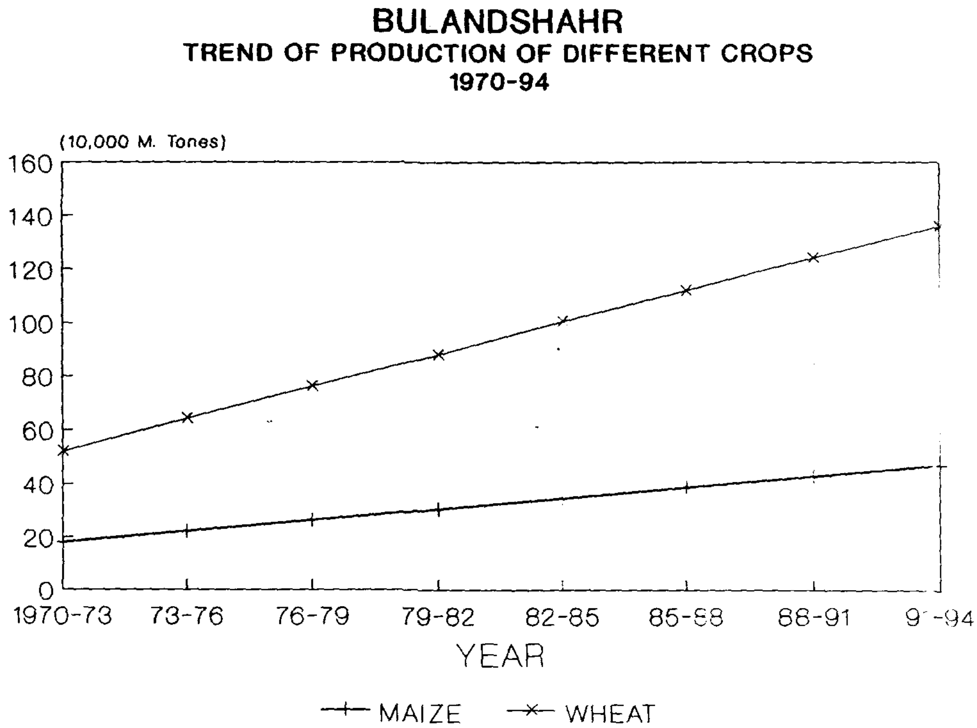
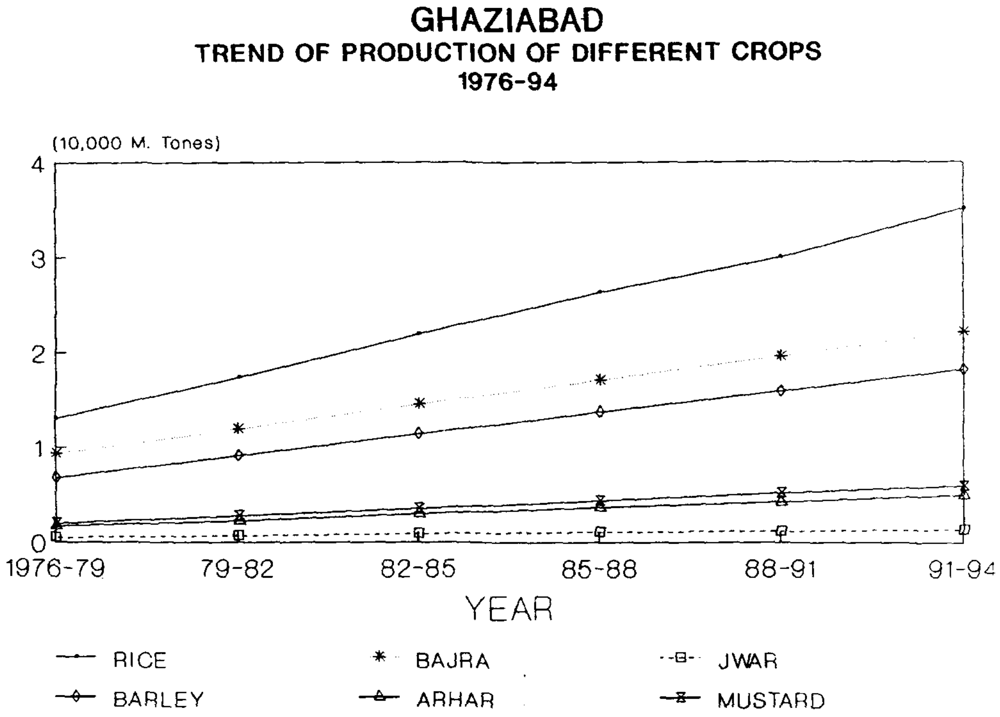

BULANDSHAHR
TREND OF PRODUCTION OF DIFFERENT CROPS
1970-94
(10,000 M. Tones)
160
140
120
100
80
60
40
20
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
MAIZE
WHEAT

Fig. 3.16A,B


GHAZIABAD
TREND OF PRODUCTION OF DIFFERENT CROPS
1976-94
(10,000 M. Tones)
4
3
2
1
0
1976-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
BAJRA
JWAR
BARLEY
ARHAR
MUSTARD

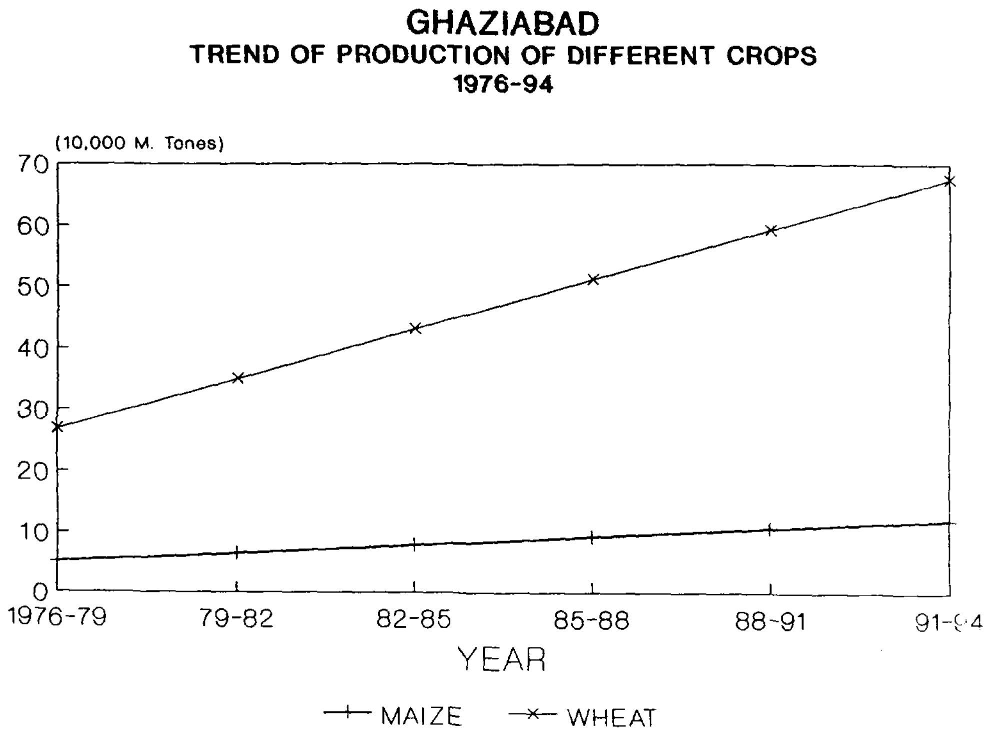

GHAZIABAD
TREND OF PRODUCTION OF DIFFERENT CROPS
1976-94
(10,000 M. Tones)
70
60
50
40
30
20
10
0
1976-79
79-82
82-85
85-88
88-91
91-94
YEAR
MAIZE
WHEAT

Fig. 3.17A,B

terms of production of the selected crops among all the crops wheat is the dominating one followed by maize and rice among the cereals, whereas sugarcane followed by potato among the cash crops. The trend line of wheat suggests that production of wheat has increased rapidly as compared to rice, maize and barley. On the other hand the trend of mustard and arhar have increased steadily. The coefficient of correlation between area and production further indicate almost positive correlation among all the crops except jwar and maize. The relationship between area and yield shows negative correlation among all the crops except rice potato, sugarcane and mustard. It further confirms that per hectare yield has increased but the area either remain constant or decline. But in case of rice, potato and sugarcane the per hectare area of yield and area under these crops has increased simultaneously. It further suggests that farmers are paying their attention towards the cash crops, which are more remunerative.

Yield Variability

Unlike the result of area and production the yield has also increased for all crops except arhar which declined 3.3 times during the period under investigating. Table 3.14 reveals the percentage change of yield and trend of selected crops in Upper Ganga-Yamuna Doab. Figures 3.18 and 3.18A, B show the trend lines of yield and percentage change of yield of selected crops in Upper Ganga-Yamuna Doab. The highest growth is observed in terms of yield per hectare in jwar which rose by 5.23 times and has also registered higher yield i.e., 1.48 times, which rose from 2.59 quintal in 1976-77 to 32.11 quintal per hectare in 1993-94. There is also a definite upward trend in case of barley (2.65 times), rice (1.53 times), sugarcane (1.31 times) and potato (1.93 times). The growth

TABLE 3.14
UPPER GANGA-YAMUNA DOAB
%AGE CHANGE OF YIELD AND TREND OF SELECTED CROPS (1976-1994)

YEAR	RICE			MAIZE			BAJRA			JWAR			WHEAT			BARLEY			POTATO			SUGARCANE			ARHAR			MUSTARD		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
1976-77	14.30	0.00	18.68	9.44	0.00	15.19	4.11	0.00	7.95	1.45	0.00	3.93	21.59	0.00	25.33	11.83	0.00	21.25	130.47	0.00	204.54	502.24	0.00	538.72	26.97	0.00	11.14	4.21	0.00	6.86
1977-78	14.63	2.35	20.46	7.84	-16.99	16.62	3.93	-4.29	8.75	2.25	54.90	4.37	18.06	-16.34	27.71	12.24	3.46	23.48	174.27	33.57	223.44	532.99	6.12	587.82	22.17	-17.82	11.99	4.69	6.55	7.54
1978-79	15.18	3.73	22.23	5.30	-32.42	18.06	1.27	-67.84	9.55	0.20	-90.99	4.81	19.77	9.47	30.09	12.55	2.51	25.71	157.53	-9.61	242.34	426.48	-19.98	636.93	5.64	-74.55	12.84	5.32	18.10	8.22
1979-80	12.15	-19.93	24.01	13.32	51.49	19.50	2.49	96.73	10.66	1.62	99.47	5.25	19.33	-2.23	32.47	13.03	3.83	27.94	197.19	25.18	261.23	450.55	5.65	686.04	7.21	27.81	13.69	3.92	-26.11	8.90
1980-81	16.41	35.00	25.79	14.12	6.03	20.94	7.04	52.97	11.16	1.34	-17.45	5.68	22.37	15.75	34.85	15.03	15.35	30.17	164.18	-16.74	280.13	489.75	8.70	735.14	5.50	-23.70	14.54	5.41	38.04	9.58
1981-82	12.28	-25.18	27.56	13.80	-2.25	22.38	8.05	14.28	11.96	0.40	-70.17	6.12	21.89	-2.16	37.23	11.44	-23.84	32.39	203.27	23.81	299.02	491.13	0.28	784.25	11.67	12.19	15.39	6.35	17.55	10.26
1982-83	16.10	31.13	29.34	14.04	1.72	23.82	9.64	19.81	12.76	4.09	45.35	6.56	23.16	5.82	39.61	16.43	43.53	34.62	191.86	-5.62	317.92	511.24	4.09	833.35	6.83	-32.91	16.24	5.05	-20.59	10.94
1983-84	18.46	14.70	31.11	14.17	5.20	25.26	8.50	-11.91	13.56	2.27	-44.57	7.00	24.07	3.91	41.99	17.27	5.05	36.85	243.26	26.79	336.82	539.13	5.46	882.46	9.68	23.66	17.10	7.07	40.20	11.62
1984-85	19.74	6.92	32.89	21.39	44.80	26.70	9.65	13.61	14.37	8.45	72.90	7.44	24.22	0.63	44.37	18.55	7.50	39.08	213.13	-12.38	555.71	433.46	-19.60	931.56	13.29	37.26	17.95	7.89	11.55	12.30
1985-86	25.04	26.95	34.67	17.45	-18.31	28.14	7.03	-27.14	15.17	3.28	-61.19	7.87	29.34	21.14	46.75	20.49	10.48	41.31	168.62	-20.88	374.61	509.32	17.50	980.67	10.98	-17.41	18.80	6.26	-20.64	12.98
1986-87	18.32	-26.91	36.44	34.61	98.31	29.58	13.32	93.35	15.97	4.20	28.07	8.31	25.58	-12.83	49.13	21.15	3.21	43.54	243.19	44.22	393.50	541.21	6.26	1029.77	10.13	-10.73	19.65	6.22	-0.69	13.66
1987-88	18.55	1.29	38.22	11.49	-66.80	31.01	7.85	-41.03	16.77	3.62	-13.76	8.75	25.55	-0.09	51.51	22.89	8.21	45.77	226.93	-6.76	412.41	572.07	5.70	1078.88	11.03	8.92	20.50	5.87	-5.63	14.34
1988-89	22.23	19.81	40.00	13.48	17.31	32.54	10.51	33.88	17.58	6.85	89.01	9.19	30.09	17.76	53.89	29.63	29.45	48.00	211.93	-6.54	431.30	546.70	-4.44	1127.98	8.77	-20.45	21.35	8.67	47.71	15.03
1989-90	20.39	-8.27	41.77	18.72	16.62	33.89	7.42	-29.44	18.38	5.14	-24.95	9.63	29.50	-1.97	56.27	28.19	-4.86	50.22	211.83	-0.05	450.19	607.22	11.07	1177.09	12.32	40.40	22.60	8.42	-2.86	15.71
1990-91	22.95	12.56	43.55	18.93	20.41	35.33	11.85	59.74	19.18	7.32	42.44	10.06	29.19	-1.06	58.65	30.76	9.11	52.45	227.90	7.58	469.09	624.74	2.89	1226.19	9.77	-20.67	23.05	9.86	17.03	16.39
1991-92	22.66	-1.30	45.32	12.70	-32.88	36.77	10.69	-9.81	19.98	4.31	-41.14	10.50	28.50	-2.35	61.03	32.17	4.60	54.68	230.30	1.05	487.98	656.09	5.02	1275.30	10.31	5.44	23.90	8.43	-14.42	17.07
1992-93	24.94	10.10	47.10	19.30	51.94	38.21	11.74	9.85	20.79	6.40	48.47	10.94	31.56	10.73	63.41	37.49	16.53	56.91	233.70	1.47	506.88	603.64	-7.99	1324.40	8.32	-19.29	44.76	9.77	15.85	17.75
1993-94	21.95	-12.01	48.88	15.63	-19.01	39.65	7.98	-31.98	21.59	7.59	18.58	13.38	32.11	1.76	65.79	31.39	-16.29	59.14	252.42	8.01	525.78	658.98	9.17	1373.51	8.90	6.06	25.61	10.29	4.97	18.43

NOTE : A = AREA, B = SIMPLE GROWTH, C = TREND

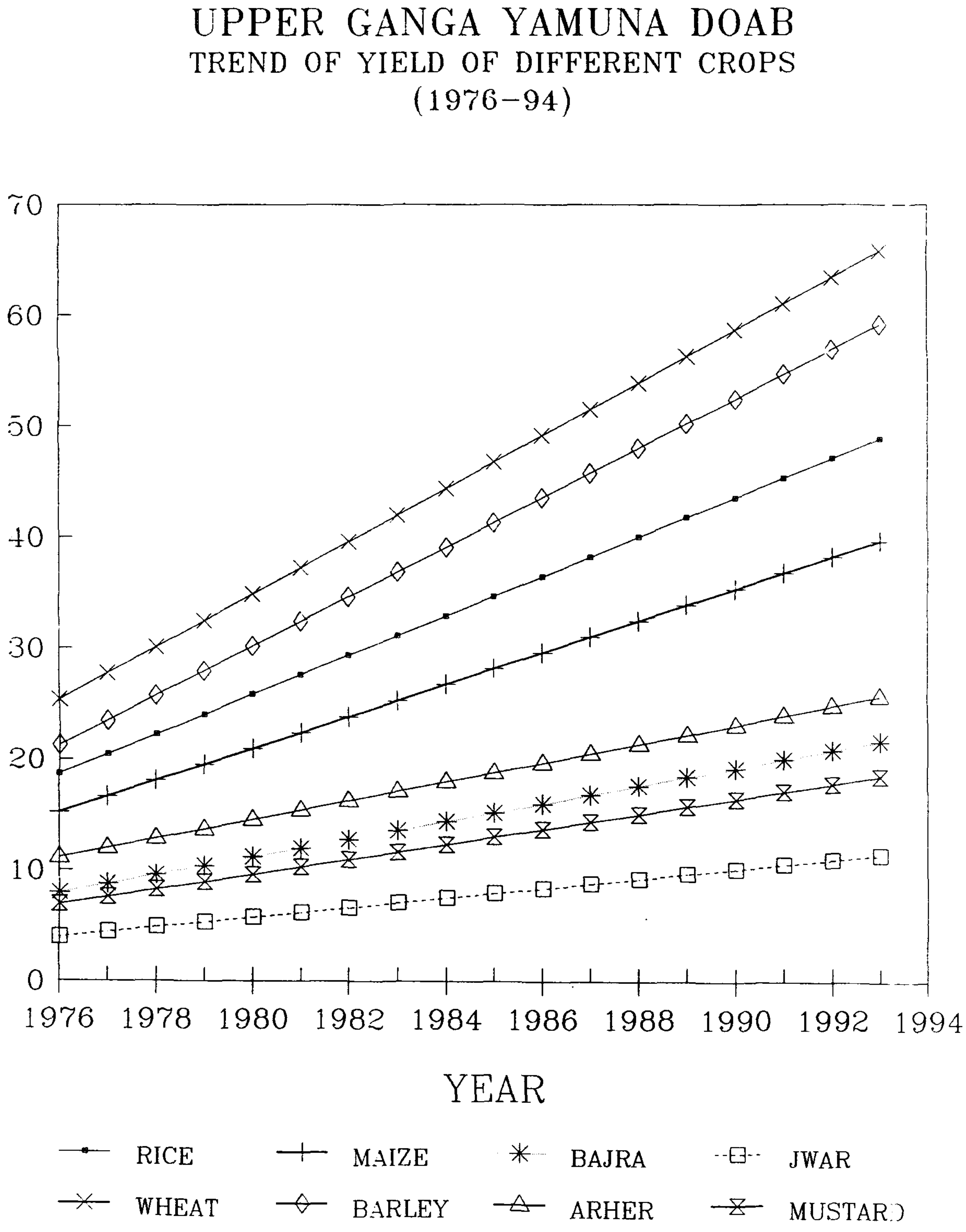
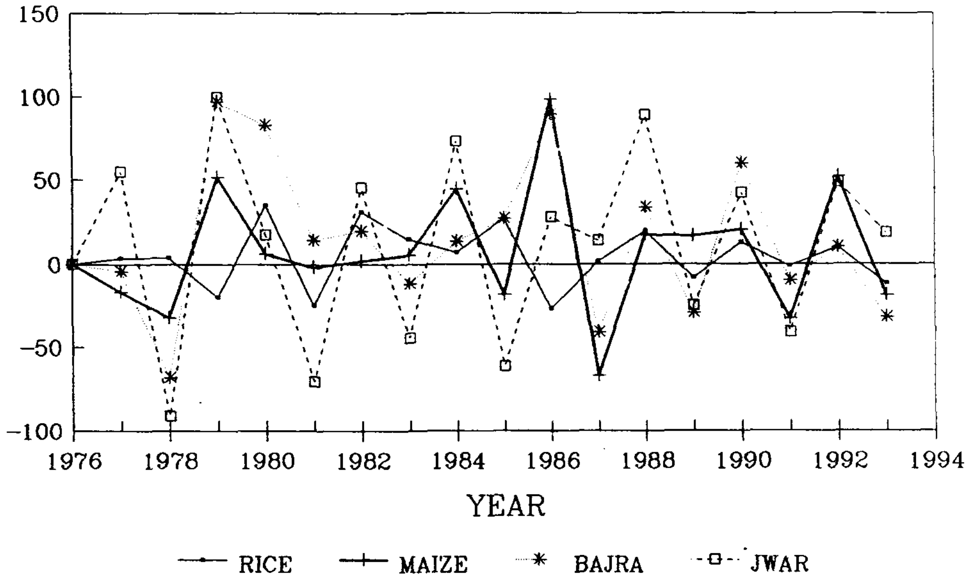

UPPER GANGA YAMUNA DOAB
TREND OF YIELD OF DIFFERENT CROPS
(1976-94)
70
60
50
40
30
20
10
0
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
YEAR
RICE
MAIZE
BAJRA
JWAR
WHEAT
BARLEY
ARHER
MUSTARD

Fig. 3.18

UPPER GANGA YAMUNA DOAB
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
(1976-94)



UPPER GANGA YAMUNA DOAB
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
(1976-94)

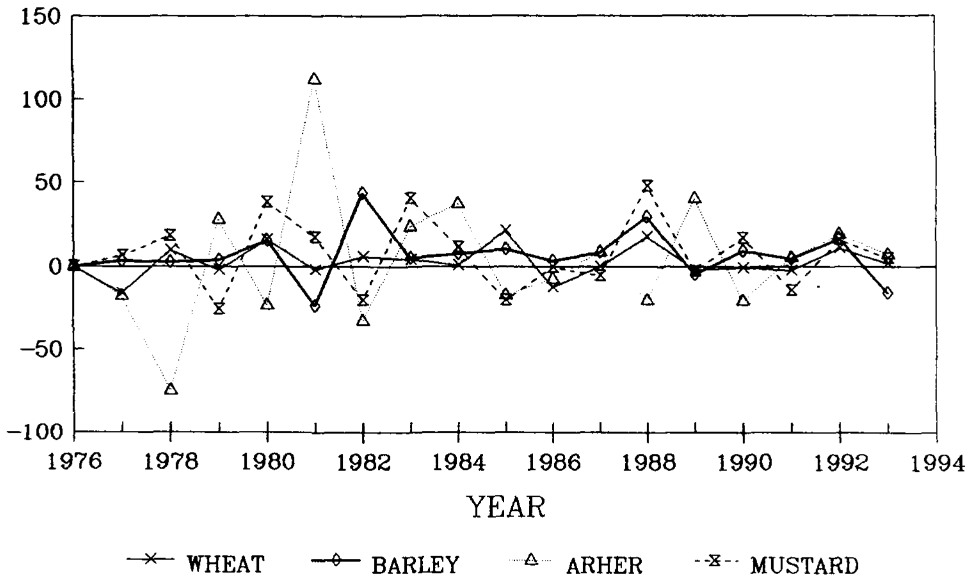


Fig. 3.18A,B

behaviour of yield is almost similar to the growth in production levels. However, in case of barley the area and production tended to decline but yield per hectare has increased to about 2.65 times. On the contrary yield of arhar declined 3.29 times, while area and production have increased. Table 3.15 reveals percentage change of yield of selected crops in different districts of Upper Ganga-Yamuna Doab from 1970 to 1994, based on three years moving averages The above table indicates the variation of yield of different crops. Figures 3.19A,A1 and B, B1 display the trend lines of the yield and percentage change of yield of selected crops in Saharanpur district. Like area and production of different crops in Saharanpur district, yield has also increased of all the crops. But the rate of increase among all the crops is varying at the rate of +2.14 times to -2.50 times. The highest increase in the level of yield i.e., quintal per hectare is registered in potato followed by rice, bajra, jwar and wheat. Potato accounts 2.49 times and rice 2.14 times growth of the yield from 1970-73 to 1991-94. As far as trend of yield of ten crops is concern, Table 3.15 and Figures 3.20 and 3.20A, B reveal the rising trend except arhar, which shows negative growth. Out of ten crops, three crops such as maize, bajra and barley indicate the growth of yield per hectare tremendously without increasing its area, whereas rice, jwar, potato, sugarcane and mustard indicate the growth of yield per hectare simultaneously with increase in both area and production. Whereas the yield of wheat has also increased without the increase of area. This implies that per hectare productivity has increased tremendously with the use of high yielding variety of seeds and other inputs Figures 3.21C, C1 and D, D1. In Muzaffarnagar district the growth of yield quintal per hectare

TABLE 3.15

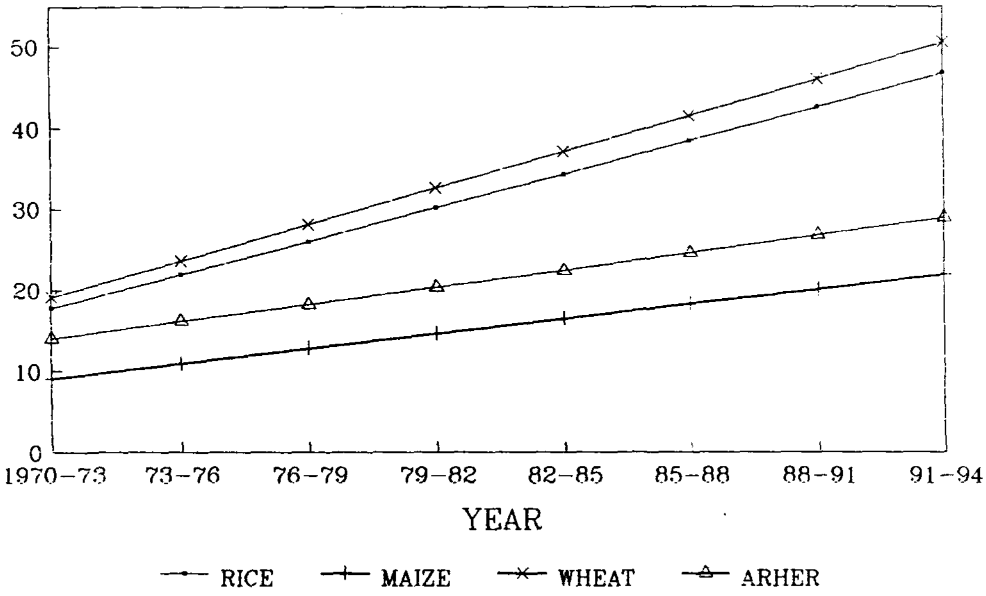
UPPER GANGA-YAMUNA DOAB

%AGE CHANGE OF YIELD AND TREND OF SELECTED CROPS (1970-1994)

YEAR	RICE			MAIZE			BAJRA			JWAR			WHEAT			BARLEY			POTATO			SUGARCANE			ARHAR			MUSTARD		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
SAHARANPUR																														
1970-73	10.94	0.00	17.74	8.56	0.00	9.04	4.77	0.00	6.17	2.62	0.00	3.43	13.93	0.00	19.12	6.72	0.00	16.44	94.96	0.00	176.78	459.82	0.00	534.34	23.13	0.00	13.97	4.41	0.00	6.30
1973-76	11.53	5.37	21.89	6.58	-23.08	10.88	2.72	-42.88	7.74	2.18	-16.83	4.31	9.93	-28.70	23.62	9.66	43.66	21.01	111.13	17.02	218.10	681.04	48.11	644.63	19.91	-13.95	16.11	5.98	35.38	7.74
1976-79	15.67	35.84	26.04	7.56	14.83	12.73	2.87	5.31	9.31	1.17	-46.58	5.18	16.14	52.42	28.11	10.18	5.39	25.38	149.98	34.94	259.43	483.21	-29.05	754.92	21.79	9.46	18.25	4.78	-20.54	9.18
1979-82	15.67	-0.89	30.19	9.25	22.36	14.58	3.41	18.83	10.88	0.65	-43.89	6.06	16.86	4.49	32.60	11.94	17.27	29.75	190.36	26.94	300.76	486.03	0.58	865.21	7.58	-65.22	20.38	5.56	17.06	10.62
1982-85	18.93	21.69	34.34	12.94	39.92	16.42	6.68	65.98	12.45	5.66	60.16	6.93	21.80	29.31	37.10	15.74	31.88	34.12	216.06	13.50	342.08	365.23	-24.85	975.50	11.01	45.28	22.52	7.00	25.95	12.06
1985-88	23.76	25.49	38.49	11.77	-9.02	18.47	9.34	39.71	14.03	2.99	-47.15	7.81	22.97	5.36	41.59	19.88	26.32	38.49	209.92	-2.84	383.41	561.49	53.74	1085.79	10.24	-6.99	24.66	4.50	-35.75	13.50
1988-91	22.18	6.64	42.64	11.12	3.59	20.11	8.95	-4.11	15.60	6.85	28.79	8.68	25.02	8.93	46.09	29.42	47.94	42.85	203.36	-3.12	424.73	598.55	6.60	1196.08	8.87	-13.39	26.80	8.82	50.17	14.94
1991-94	23.38	5.40	46.79	4.52	40.36	21.96	10.60	18.43	17.17	5.33	-22.19	9.56	26.31	5.16	50.58	29.57	0.51	47.22	236.50	17.28	466.06	639.34	6.81	1306.37	9.24	4.15	28.94	9.42	6.73	16.38
MUZAFFAR NAGAR																														
1970-73	12.00	0.00	17.62	3.01	0.00	11.92	8.81	0.00	7.01	2.72	0.00	3.39	16.92	0.00	22.63	6.80	0.00	17.06	94.98	0.00	177.25	493.31	0.00	553.15	22.99	0.00	14.10	4.59	0.00	6.49
1973-76	11.32	-5.61	21.50	9.98	-16.90	14.50	3.50	-60.31	8.59	2.22	-18.56	4.26	15.18	-10.28	27.84	9.86	44.85	21.58	108.14	13.85	218.85	493.72	0.08	671.41	20.43	-11.14	16.29	5.91	28.80	7.99
1976-79	15.3	35.09	25.57	7.37	-28.00	17.09	3.28	-6.72	10.17	0.83	-62.61	5.12	17.87	17.74	33.05	10.11	2.54	26.10	150.03	38.99	260.45	498.64	0.10	679.68	21.77	6.58	18.47	4.37	-26.07	9.49
1979-82	14.16	7.42	29.65	10.46	41.95	19.68	5.29	62.11	11.75	1.04	25.44	5.99	22.21	24.26	38.26	11.94	8.09	30.32	188.73	25.56	302.05	506.22	1.52	907.94	7.49	-65.62	20.66	5.49	25.60	10.98
1982-85	19.66	38.81	33.73	13.72	31.19	22.27	8.21	55.30	13.33	4.28	11.23	6.85	22.59	1.73	43.46	15.73	31.82	35.14	215.84	14.36	343.64	571.38	13.27	1026.20	9.73	29.92	22.85	6.86	25.09	12.48
1985-88	18.47	-6.02	37.81	13.22	-3.65	24.86	9.40	14.48	14.90	4.41	2.96	7.72	26.75	18.39	58.67	20.25	28.72	39.66	213.51	-1.08	385.24	572.77	-0.11	1144.47	10.21	4.94	25.04	6.39	-6.97	13.98
1988-91	23.47	27.05	41.89	14.55	10.09	27.45	8.25	-12.24	16.48	6.39	45.10	8.58	29.04	8.55	53.88	29.63	46.29	44.18	207.59	-2.78	426.84	620.21	8.28	1262.73	10.99	7.62	27.23	8.88	39.10	15.48
1991-94	24.96	6.36	45.98	14.01	-3.72	30.04	9.38	13.72	18.06	5.24	-18.06	9.45	33.47	4.94	59.09	32.15	8.52	48.70	238.92	15.09	468.44	666.94	7.54	1380.99	9.17	-16.52	29.43	9.42	6.04	16.98
MEERUT																														
1970-73	11.15	0.00	15.25	11.14	0.00	13.09	3.50	0.00	6.08	3.82	0.00	3.66	16.39	0.00	23.75	9.87	0.00	17.47	94.95	0.00	178.25	474.49	0.00	522.48	22.94	0.00	10.41	4.60	0.00	6.56
1973-76	9.72	-12.61	18.90	8.91	-22.35	16.04	1.89	-45.36	7.65	2.14	-43.98	4.58	15.18	-7.39	29.25	10.62	7.60	21.98	98.80	4.05	220.46	484.87	2.29	632.61	2.37	-89.68	12.23	5.83	26.83	9.08
1976-79	11.08	13.98	22.54	7.16	-19.61	18.99	1.85	-2.17	9.22	1.08	-49.57	5.49	19.39	27.74	34.75	10.09	4.94	26.49	149.63	51.46	262.66	494.46	1.98	642.75	12.23	48.29	14.06	4.75	-18.57	9.59
1979-82	10.94	-1.31	26.18	13.72	91.63	21.95	5.43	93.56	10.79	1.22	12.63	6.40	22.47	15.89	40.55	11.73	16.25	31.00	197.81	32.20	304.86	492.34	-0.43	852.88	7.82	-36.01	15.8	5.64	18.76	11.10
1982-85	16.25	48.63	29.82	16.82	22.59	24.90	9.88	81.90	12.36	4.50	69.72	7.32	25.20	12.16	45.75	15.71	33.88	35.51	204.68	3.49	347.06	520.66	5.75	963.01	10.49	34.05	17.71	7.02	24.50	12.61
1985-88	19.70	21.18	33.48	14.04	-16.50	27.86	9.28	-6.17	13.93	3.75	-16.60	8.23	29.74	17.99	51.25	20.01	27.40	40.02	225.33	10.08	389.26	510.64	-1.92	1023.15	10.34	-1.39	19.53	6.37	-9.25	14.12
1988-91	20.78	5.50	37.10	16.35	16.42	30.81	6.13	-33.87	15.49	6.39	70.30	9.14	32.52	9.36	56.75	29.53	47.58	54.53	212.58	-5.66	431.46	584.79	14.52	1183.28	7.87	-23.86	21.36	8.89	39.67	15.63
1991-94	22.42	7.87	40.74	16.23	-0.74	33.76	10.70	74.53	17.06	4.41	-0.39	10.06	29.30	-10.43	52.25	32.19	8.98	49.04	242.26	13.97	473.66	617.16	5.61	1293.41	9.18	16.64	23.18	9.44	6.10	17.14
BULANDSHAHR																														
1970-73	9.59	0.00	12.32	13.58	0.00	15.38	6.06	0.00	7.50	2.94	0.00	3.61	21.26	0.00	24.98	12.64	0.00	19.36	94.79	0.00	176.40	376.82	0.00	476.36	23.45	0.00	13.89	4.50	0.00	6.61
1973-76	10.41	8.45	15.07	10.48	-22.74	18.85	4.00	-33.98	9.30	2.15	-26.90	4.52	16.35	-23.11	30.66	13.32	5.42	24.15	112.55	18.74	217.18	416.96	10.65	579.97	20.88	-10.95	16.06	5.98	32.92	8.14
1976-79	13.60	30.66	17.82	7.43	-79.11	22.32	3.26	-18.63	11.11	2.48	-31.14	5.44	19.91	21.79	36.55	12.70	-4.65	28.95	165.20	46.77	257.96	443.74	6.42	683.59	17.75	-14.98	18.23	4.68	-21.77	9.66
1979-82	9.65	-29.03	20.57	14.88	15.23	25.79	5.60	35.77	12.91	1.15	-22.48	6.35	23.16	18.36	42.03	13.42	5.62	33.75	185.22	12.12	298.74	465.86	4.99	787.20	8.04	-54.71	20.40	5.76	23.11	11.19
1982-85	9.17	-4.99	23.32	18.29	22.84	28.26	10.45	46.72	14.72	4.90	26.81	7.27	24.87	7.36	47.71	17.88	33.31	38.54	216.45	16.86	339.52	466.20	0.07	890.82	10.28	27.87	22.57	6.97	21.01	12.72
1985-88	11.88	29.61	26.07	24.35	33.09	32.73	10.19	-2.50	16.52	3.72	-24.01	8.18	28.74	15.57	53.40	21.78	21.79	43.34	203.40	-6.30	380.30	516.61	10.81	994.43	10.96	6.57	24.74	6.39	-8.32	14.24
1988-91	17.05	43.47	28.82	17.09	-29.81	36.20	10.47	2.79	18.32	6.54	75.63	9.09	31.63	10.03	59.08	29.47	35.30	48.14	207.73	2.13	421.08	516.56	-0.01	1098.04	10.60	-3.26	26.92	9.02	41.12	15.77
1991-94	17.18	0.76	31.58	16.91	-1.03	39.67	9.95	4.90	20.13	6.00	-6.22	10.01	33.89	7.17	64.77	33.63	14.10	52.94	225.05	8.74	461.85	608.11	17.72	1201.66	9.14	-13.79	29.09	9.59	6.40	17.30
GHAZIABAD																														
1976-79	10.83	0.00	14.34	8.83	0.00	14.25	3.49	0.00	7.64	0.96	0.00	3.89	18.11	0.00	25.44	10.14	0.00	20.11	149.03	0.00	210.01	494.88	0.00	507.89	18.89	0.00	11.28	4.83	0.00	7.16
1979-82	4.39	-59.43	19.10	15.36	73.95	18.44	6.68	61.28	10.14	1.11	14.62	5.31	21.84	20.59	33.26	11.83	16.69	27.17	141.80	21.99	273.22	353.93	-32.12	658.64	7.91	-42.30	14.01	5.58	15.55	9.38
1982-85	15.99	64.09	23.87	16.20	5.44	22.84	7.14	6.93	12.64	4.96	48.32	6.74	24.29	11.24	41.07	15.74	33.09	34.23	229.42	26.19	326.44	523.89	55.95	809.38	7.22	29.26	16.75	8.16	46.33	11.61
1985-88	15.39	-3.73	28.63	14.13	-12.78	26.83	8.35	16.95	15.12	3.90	-21.25	8.16	26.64	9.67	48.89	20.13	27.87	41.28	211.78	-7.69	399.66	497.25	-5.08	960.13	9.24	-4.70	19.48	6.37	-21.95	13.83
1988-91	17.92	16.41	33.39	14.19	0.46	21.03	9.81	17.57	17.62	6.43	64.74	9.59	29.37	10.27	56.70	29.57	46.87	48.34	238.95	12.83	462.88	561.12	12.84	1110.88	11.77	20.84	5.21	8.90	39.72	16.05
1991-94	21.54	20.21	38.15	16.76	18.08	25.22	10.38	5.76	20.11	5.98	-7.06	11.01	32.40	10.30	64.52	33.25	12.46	55.40	249.05	4.23	526.10	634.25	13.03	1261.63	9.30	-22.47	24.95	9.13	2.60	18.27

NOTE : A = AREA, B = SIMPLE GROWTH, C = TREND

SAHARANPUR
TREND OF YIELD OF DIFFERENT CROPS
1970-94



SAHARANPUR
TREND OF YIELD OF DIFFERENT CROPS
1970-94

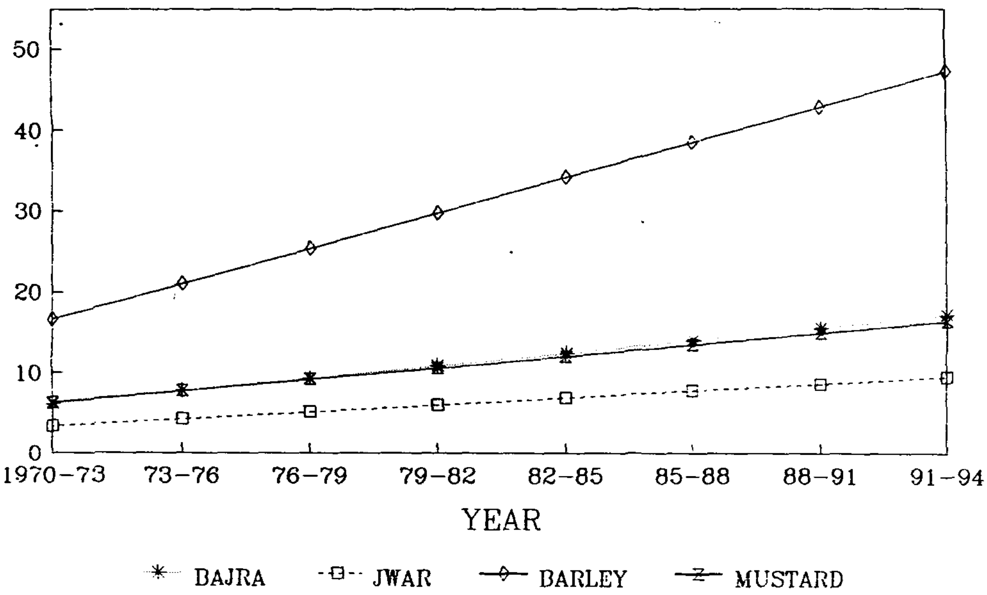
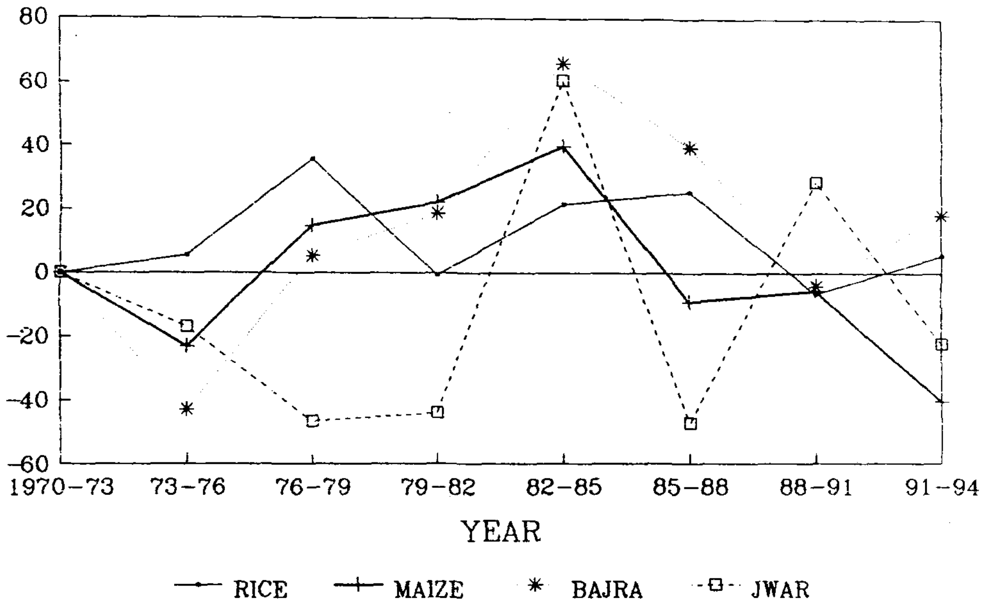


Fig. 3.19A,B

SAHARANPUR
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
1970-94



SAHARANPUR
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
1970-94

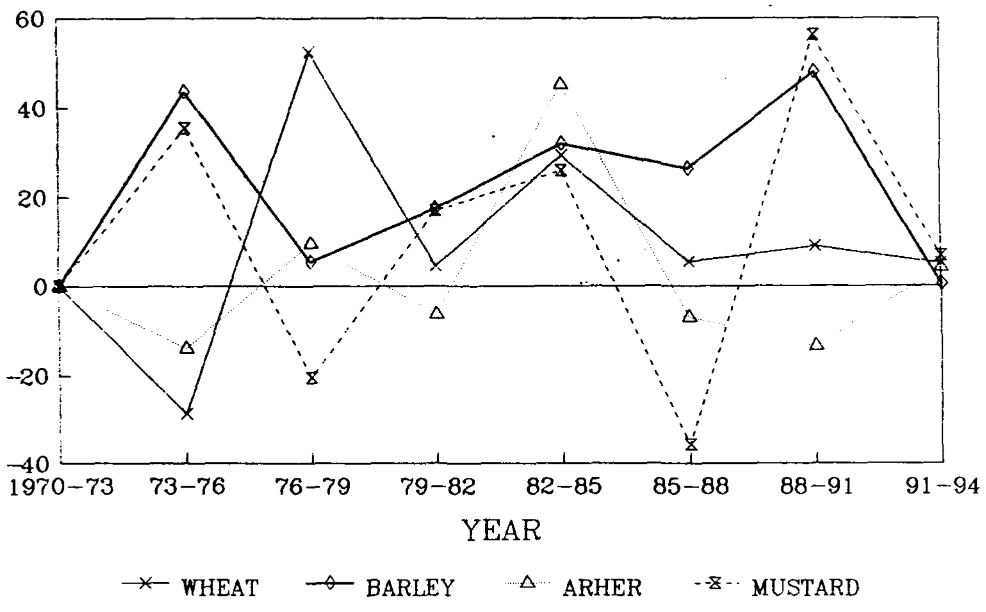


Fig.3.19A1,B1

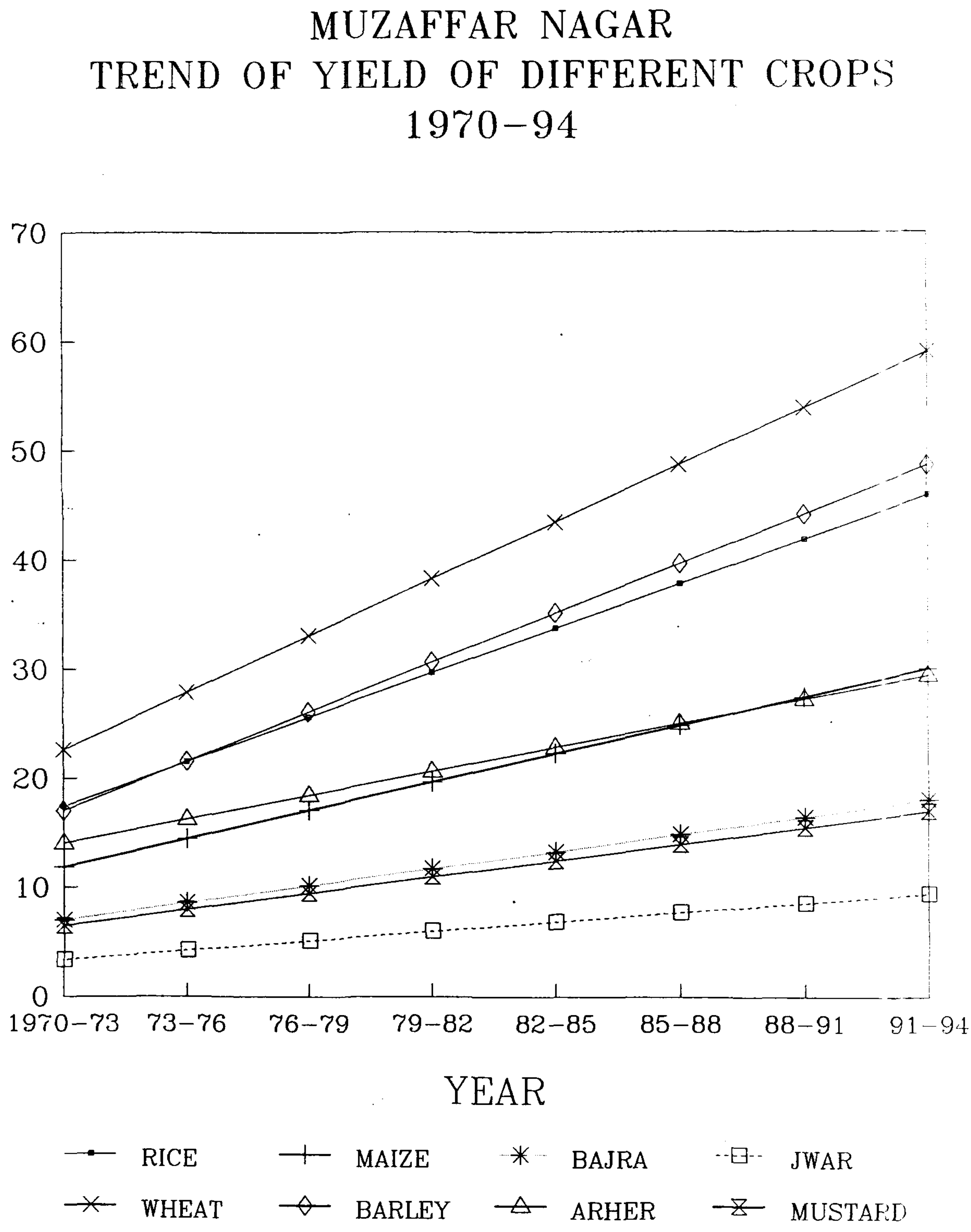
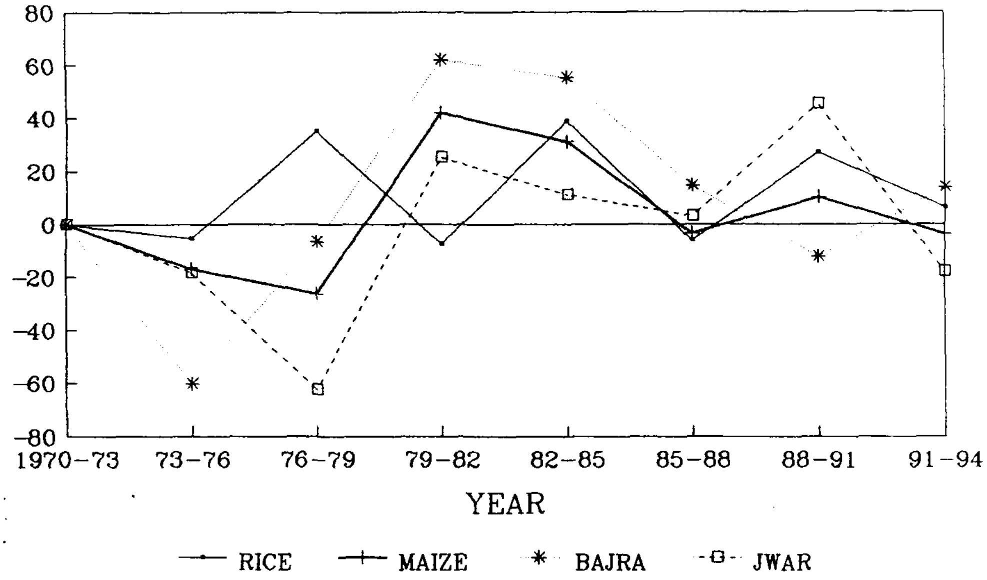

MUZAFFAR NAGAR
TREND OF YIELD OF DIFFERENT CROPS
1970-94
70
60
50
40
30
20
10
0
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
BAJRA
JWAR
WHEAT
BARLEY
ARHER
MUSTARD

Fig. 3.20

MUZAFFAR NAGAR
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
1970-94



MUZAFFAR NAGAR
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
1970-94

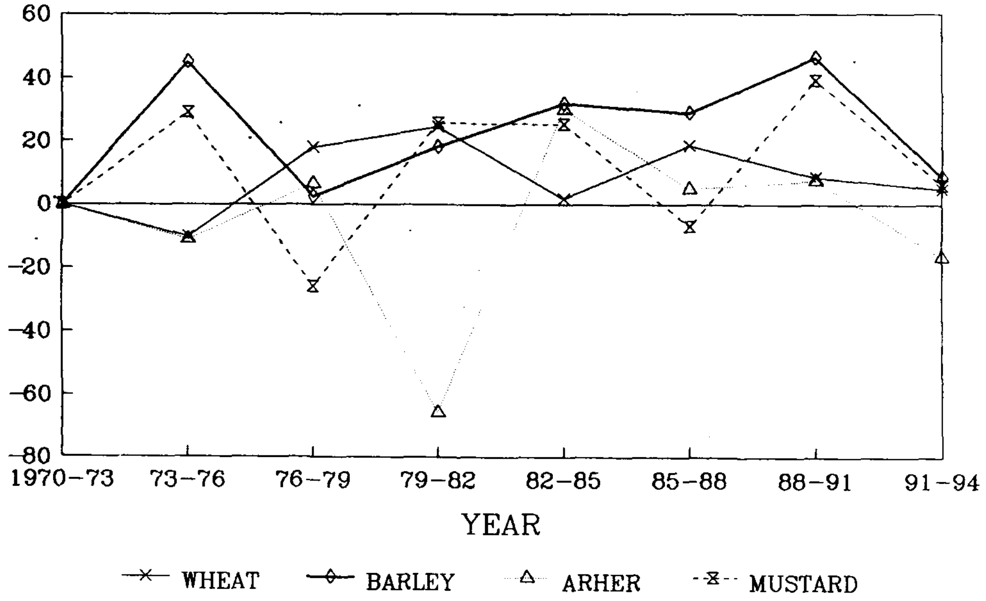
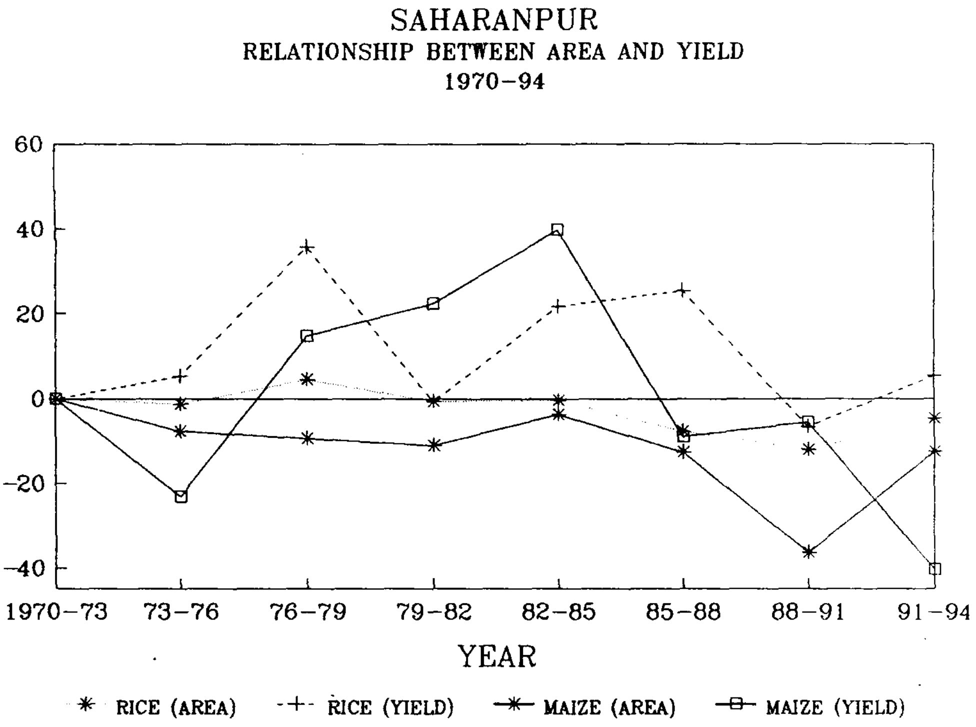


Fig. 3.20A,B


SAHARANPUR
RELATIONSHIP BETWEEN AREA AND YIELD
1970-94
60
40
20
0
-20
-40
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE (AREA)
RICE (YIELD)
MAIZE (AREA)
MAIZE (YIELD)

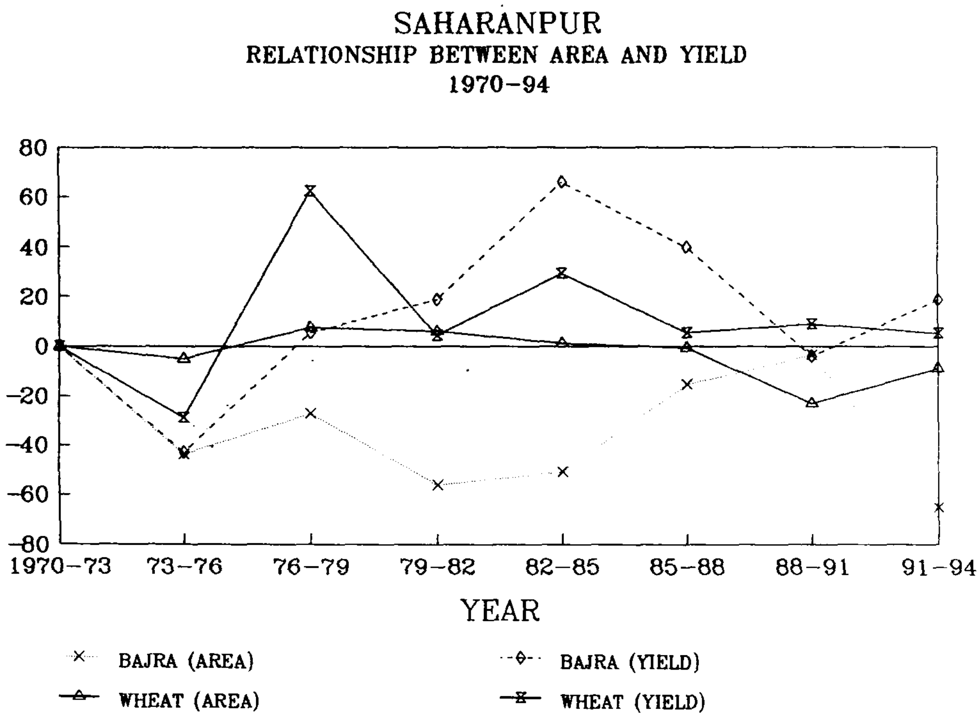
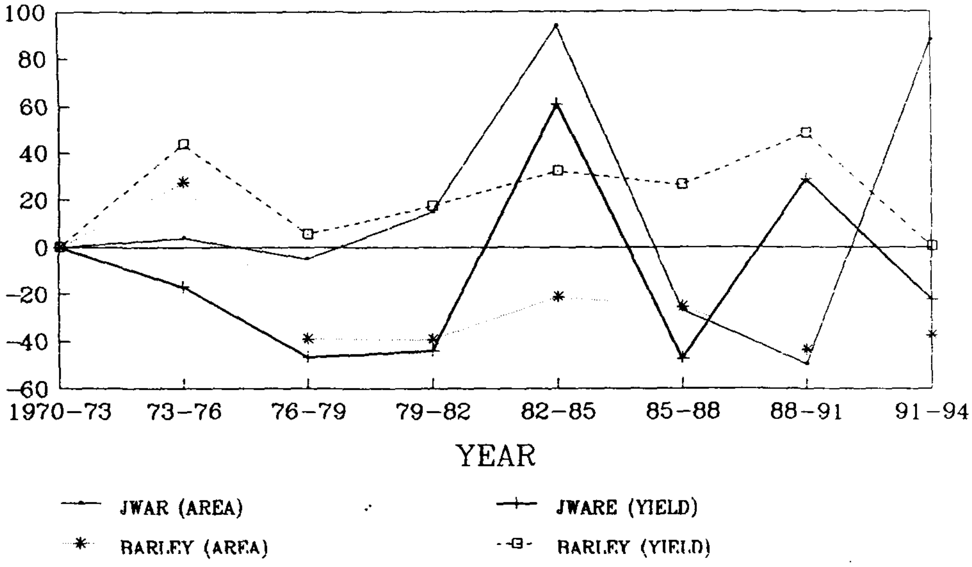

SAHARANPUR
RELATIONSHIP BETWEEN AREA AND YIELD
1970-94
80
60
40
20
0
-20
-40
-60
-80
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA (AREA)
BAJRA (YIELD)
WHEAT (AREA)
WHEAT (YIELD)

Fig. 3.21C,C1

SAHARANPUR
RELATIONSHIP BETWEEN AREA AND YIELD
1970-94



SAHARANPUR
RELATIONSHIP BETWEEN AREA AND YIELD
1970-94

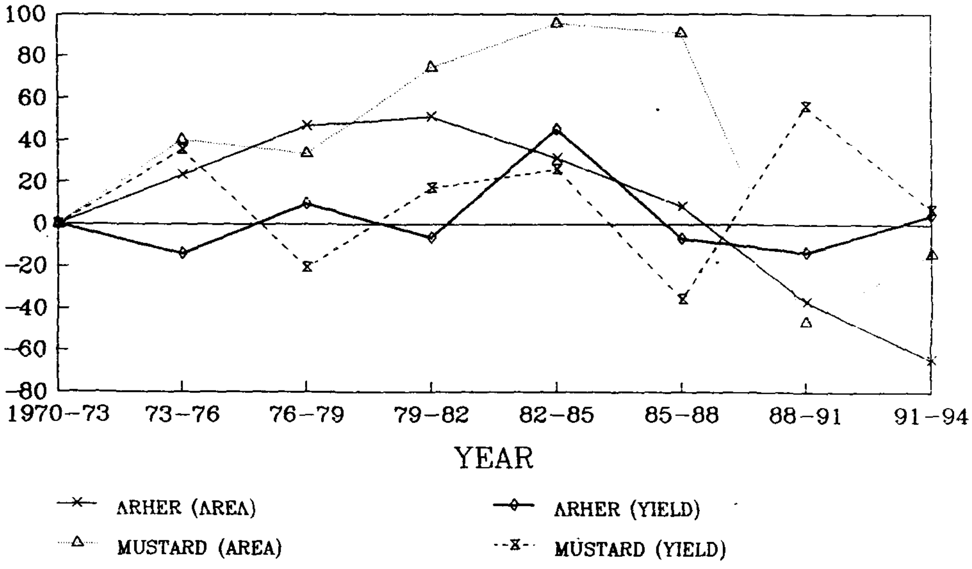
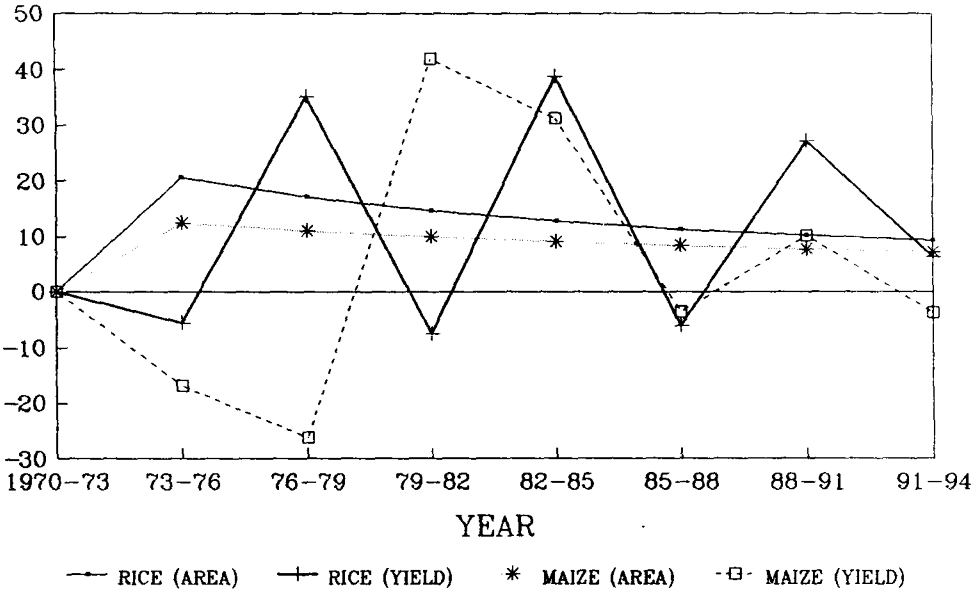


Fig. 3.21D,D1

has registered almost in same manner as it is found in Saharanpur district, but barley accounts highest growth among all the crops i.e., 4.73 times from 1970-73 to 1991-94. The yield per hectare has tremendously declined in both the districts of Saharanpur and Muzaffarnagar.

Figures 3.20 and 3.20 A, B reveal the trend of yield per hectare and percentage change of yield of all the crops taken for study. Among all the crops wheat has recorded highest trend followed by barley and rice. The relationship between area and production, and area and yield has been depicted in Table 3.12 and the relationship between area and yield has been displayed in Figures 3.21 E, E1 and F, F1. Figures reveal that out of ten crops, four crops such as rice, barley, potato and mustard have positive relationship between area and yield. It means yield is increasing with the increase in area under the above said crops. Rice has increased to 2.08 times, potato 2.52 times but barely has experienced highest growth that accounts 4.73 times from 1970-71 to 1993-94. As far as wheat is concern the yield has increased 1.98 times, though area has declined. This further strengthens the facts about the negative relationship between area and yield. It means the area has experienced high diffusion of innovations and farmers of this district were well aware about the applications of high yielding variety of seeds and other inputs, which ensured the high productivity per hect. Table 3.15 and Figure 3.14 exhibit the growth of yield and trend of different crops in Meerut district. In Meerut district out of ten selected crops, six crops such as rice, maize, barley, sugarcane, arhar and mustard have registered positive growth of yield per hectare. And the area under these crops has also increased but the production has not increased except in case of mustard, arhar and rice.

MUZAFFAR NAGAR
RELATIONSHIP BETWEEN AREA AND YIELD
1970-94



MUZAFFAR NAGAR
RELATIONSHIP BETWEEN AREA AND YIELD
1970-94

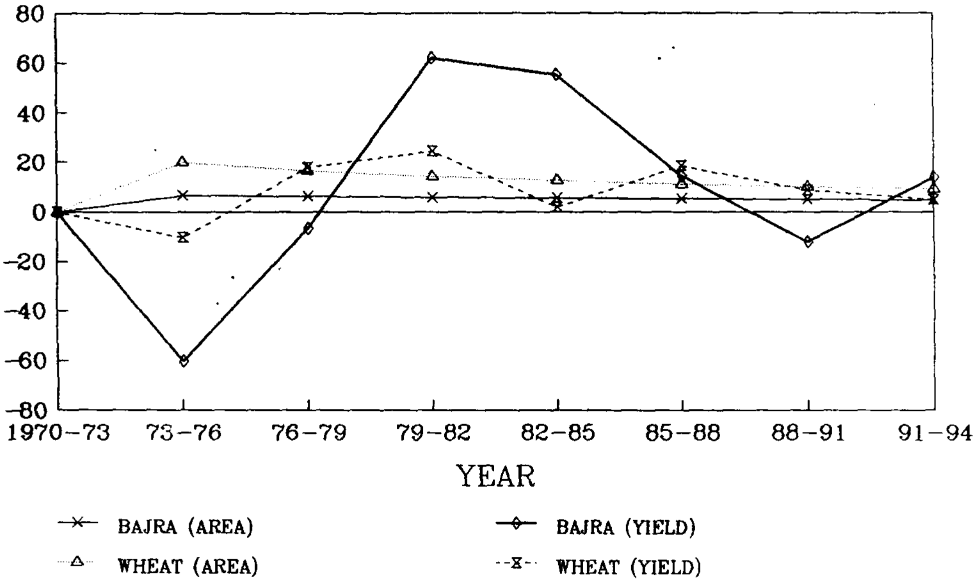
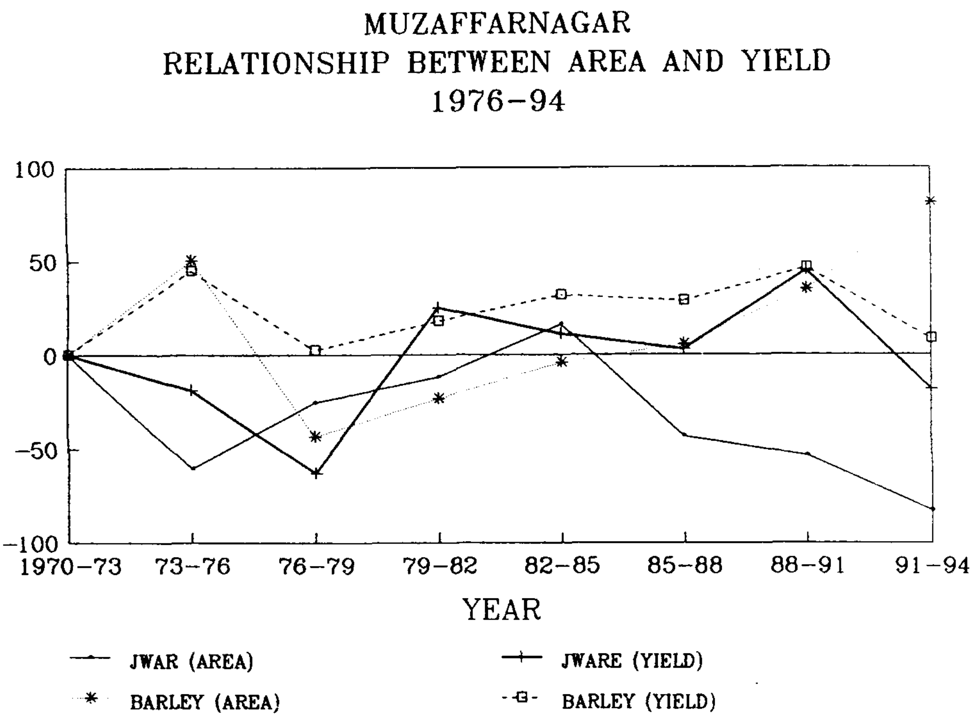


Fig. 3.21E,E1


MUZAFFARNAGAR
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94
100
50
0
-50
-100
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
JWAR (AREA)
JWARE (YIELD)
BARLEY (AREA)
BARLEY (YIELD)

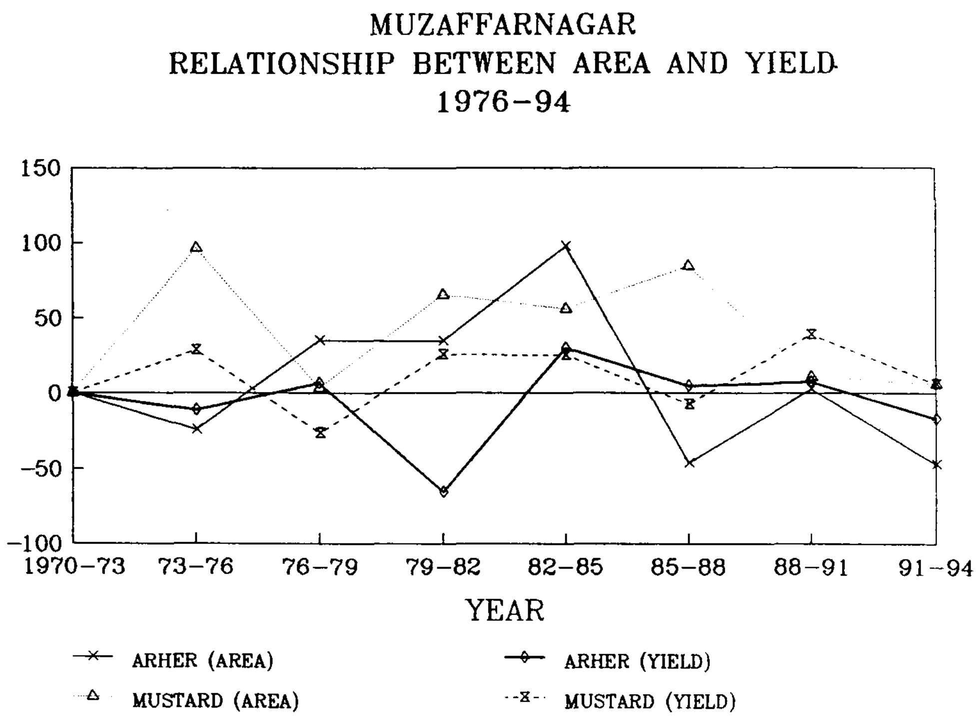
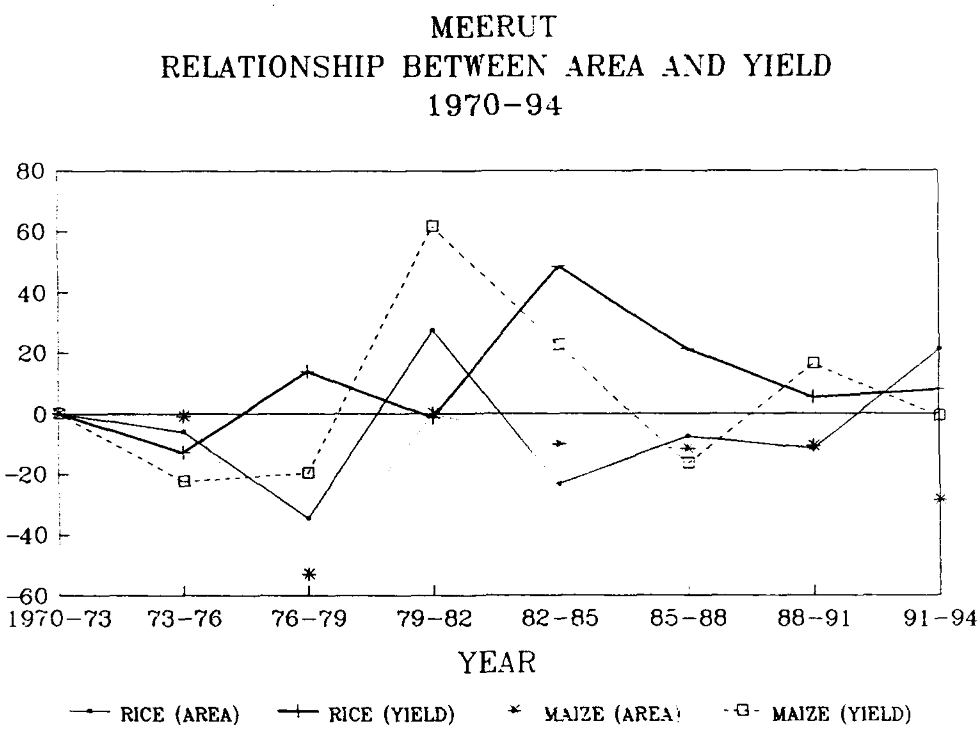

MUZAFFARNAGAR
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94
150
100
50
0
-50
-100
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
ARHER (AREA)
ARHER (YIELD)
MUSTARD (AREA)
MUSTARD (YIELD)

Fig. 3.21F,F1

Figures 3.21 G, G1 and 3.21 H, H1. In case of arhar the growth of yield per hectare has declined 2.5 times from 1970-73 to 1991-94. Though the area and production has increased. In case of potato the growth of yield secured highest position among all the crops, that account 3.26 times from the base year to the current year i.e., 1970-73 to 1990-93, though the area and production has declined. From this analysis it may be inferred that the high yielding variety of potato, wheat, jwar have tremendously been used which boosted the yield per hectare. Figures 3.14 and 3.14 A, B show the trend of yield of different crops of Meerut district in Upper Ganga-Yamuna Doab. It also reveals the growth of yield per hectare in varying degree. Table 3.15 of yield shows trend line of yield and percentage change of yield and trend of selected crops 1970-71 to 1993-94 of Bulandshahr district. Out of ten crops eight crops i.e., rice, maize, wheat, potato, sugarcane, arhar and mustard exhibit the increase of yield, area and production but the rate of increase among these crops are varied from crop to crop. Figures 3.15 and 3.15A, B implies positive correlation between yield and area. The remnant two crops bajra and jwar display the contrary picture. Here both the area and production has declined but the yield continuously increased by 1.64 and 2.04 times respectively (Figure 3.21 I, I1 and 3.21 J, J1). Arhar is the only crop, which indicates the negative growth of yield inspite of increasing area and production. As for as percentage change of yield, growth and trend of the selected crops in Ghaziabad district is concerned, the data used for the analysis starts from 1976-77 to 1993-94 because of its existence and availability of data. Table 3.15 and Figures 3.16, 3.16A and B, and Figures 3.21 K, K1 and L, L1 reveal the percentage change of yield, simple growth and


MEERUT
RELATIONSHIP BETWEEN AREA AND YIELD
1970-94
80
60
40
20
0
-20
-40
-60
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE (AREA)
RICE (YIELD)
MAIZE (AREA)
MAIZE (YIELD)

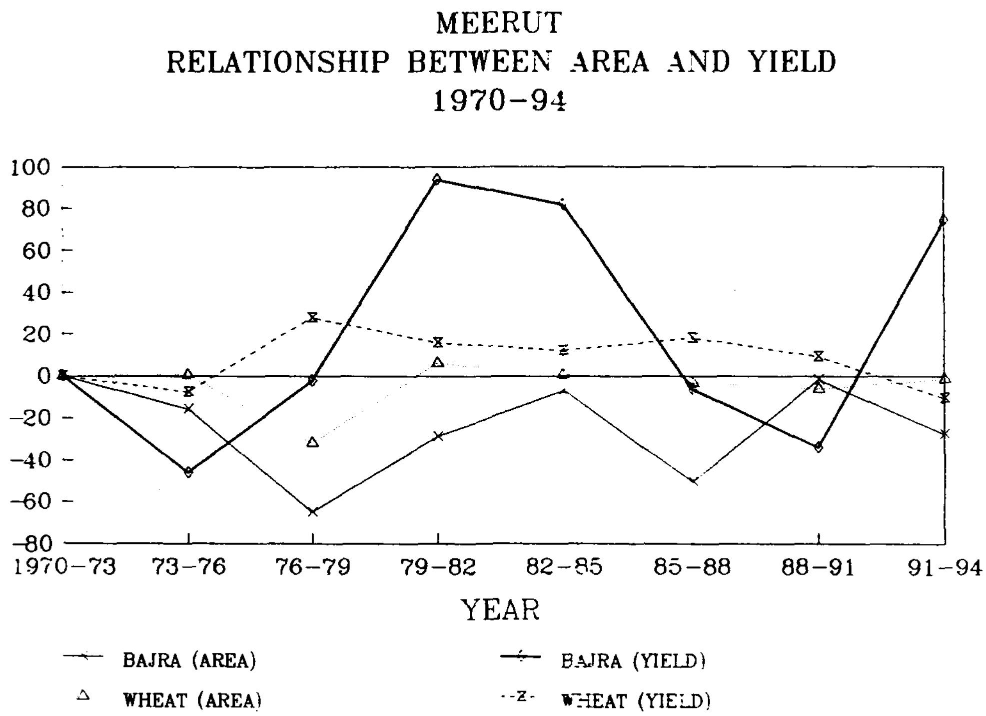
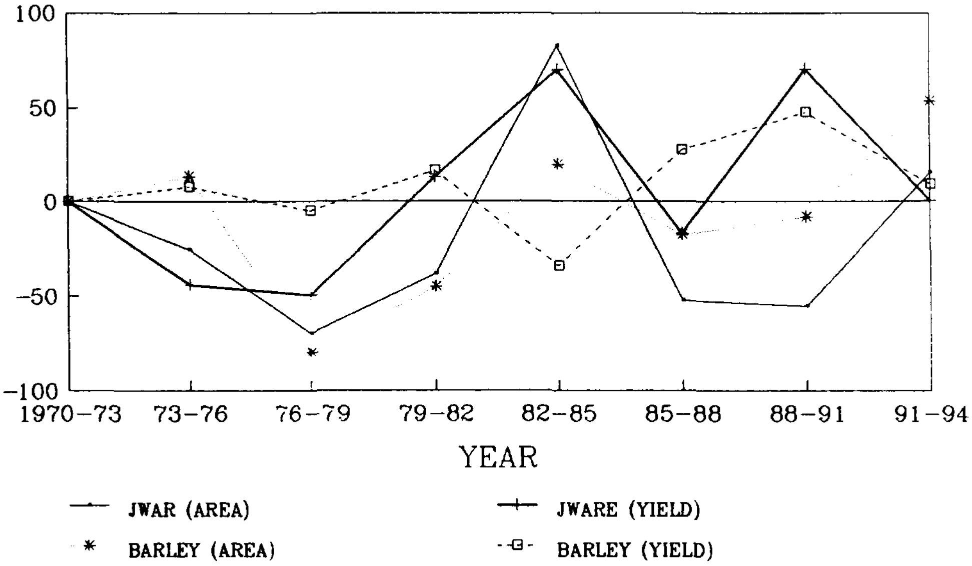

MEERUT
RELATIONSHIP BETWEEN AREA AND YIELD
1970-94
100
80
60
40
20
0
-20
-40
-60
-80
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA (AREA)
BAJRA (YIELD)
WHEAT (AREA)
WHEAT (YIELD)

Fig. 3.21G,G1

MEERUT
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94



MEERUT
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94

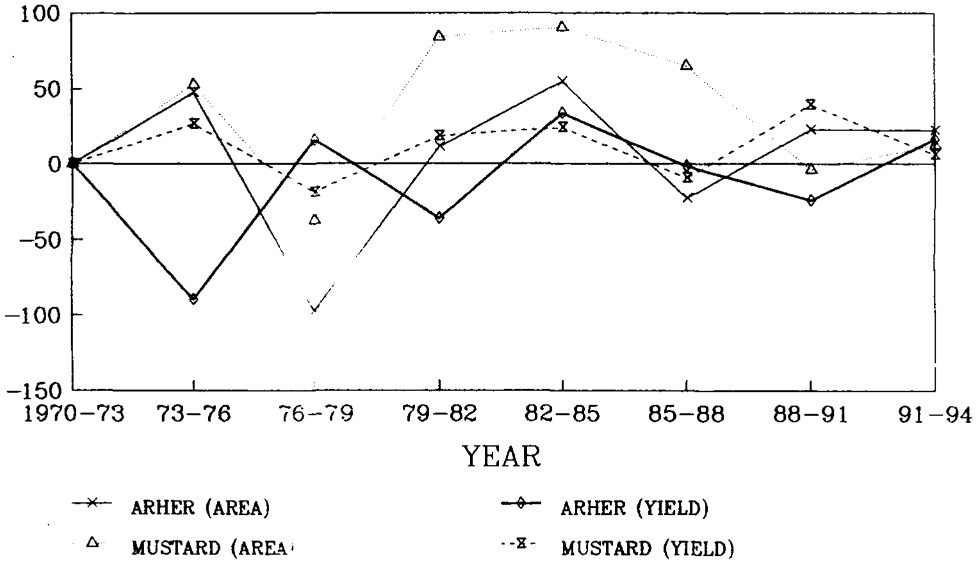


Fig. 3.21H,H1

MEERUT
TREND OF YIELD OF DIFFERENT CROPS
1970-94

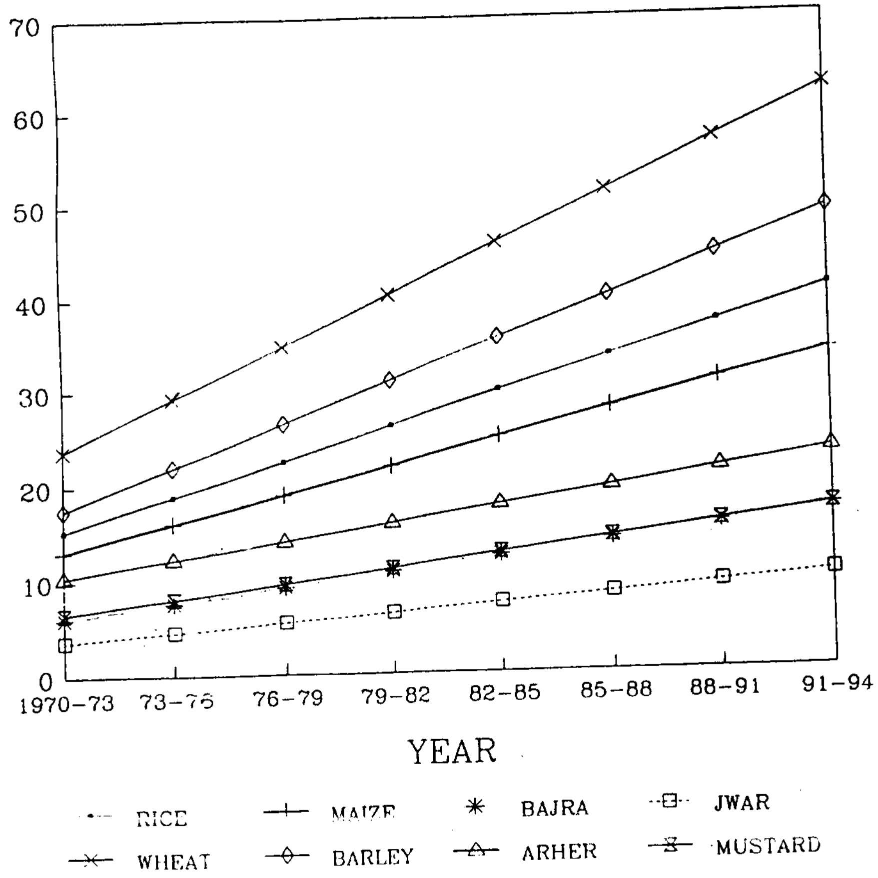


Fig. 3.14

BULANDSHAHAR
TREND OF YIELD OF DIFFERENT CROPS
1970-94

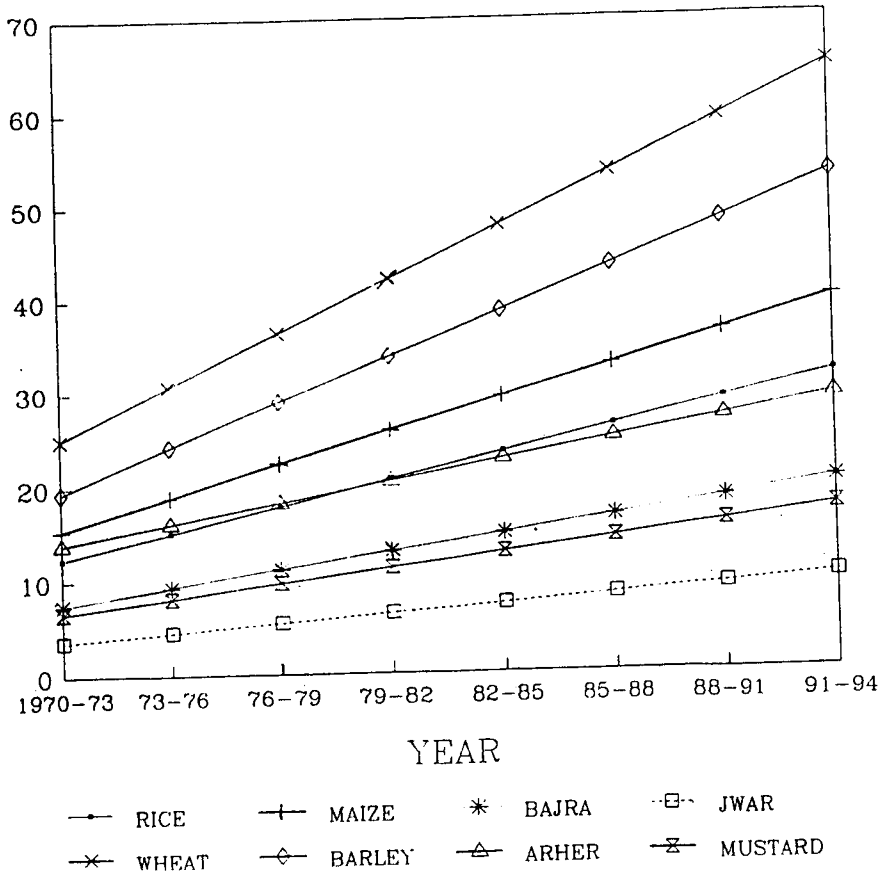
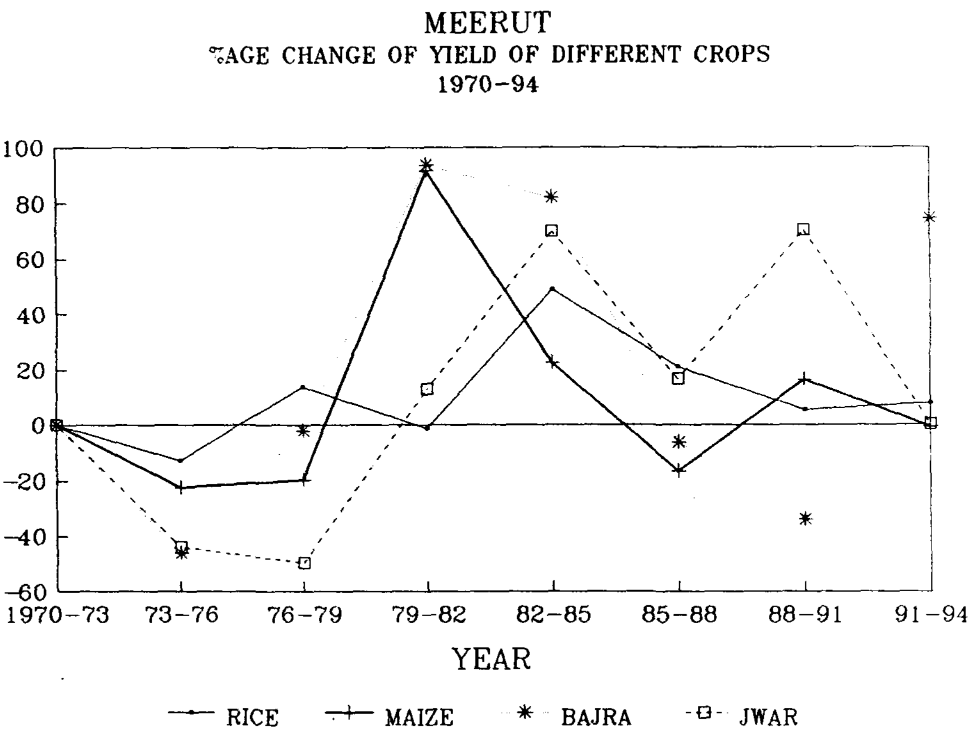


Fig.3.15


MEERUT
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
1970-94
100
80
60
40
20
0
-20
-40
-60
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE
MAIZE
BAJRA
JWAR

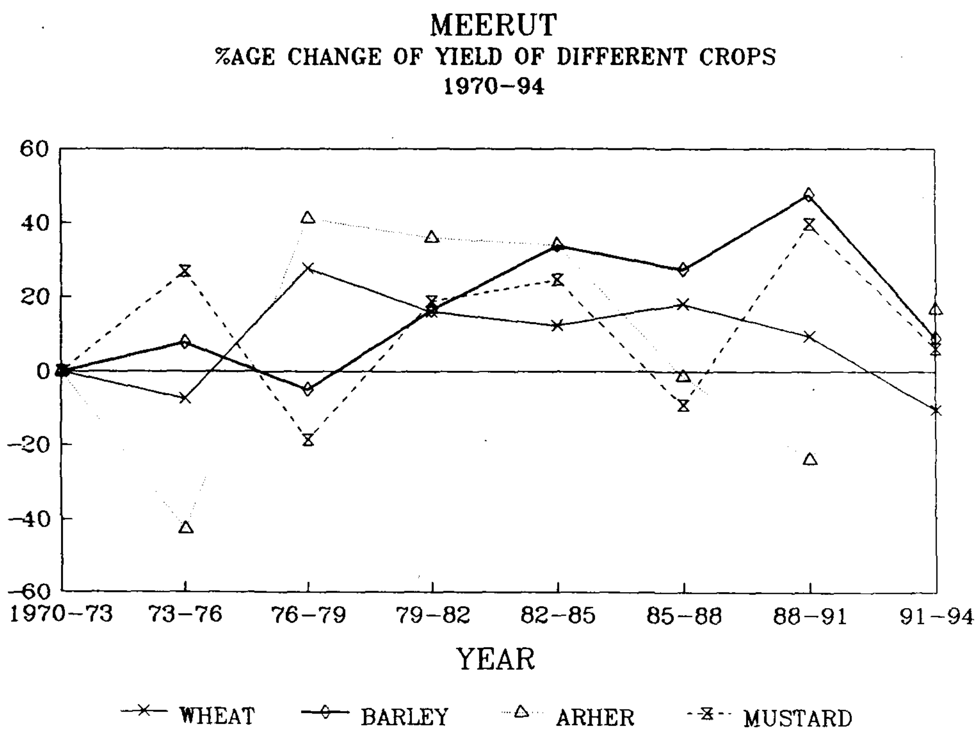
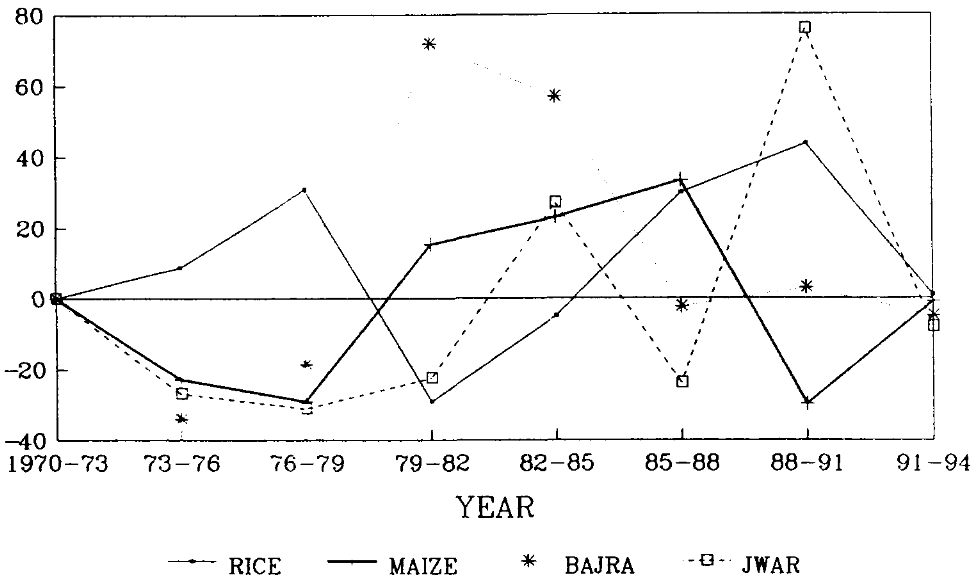

MEERUT
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
1970-94
60
40
20
0
-20
-40
-60
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
WHEAT
BARLEY
ARHER
MUSTARD

Fig. 3.14A,B

BULANDSHAHAR
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
1970-94



BULANDSHAHAR
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
1970-94

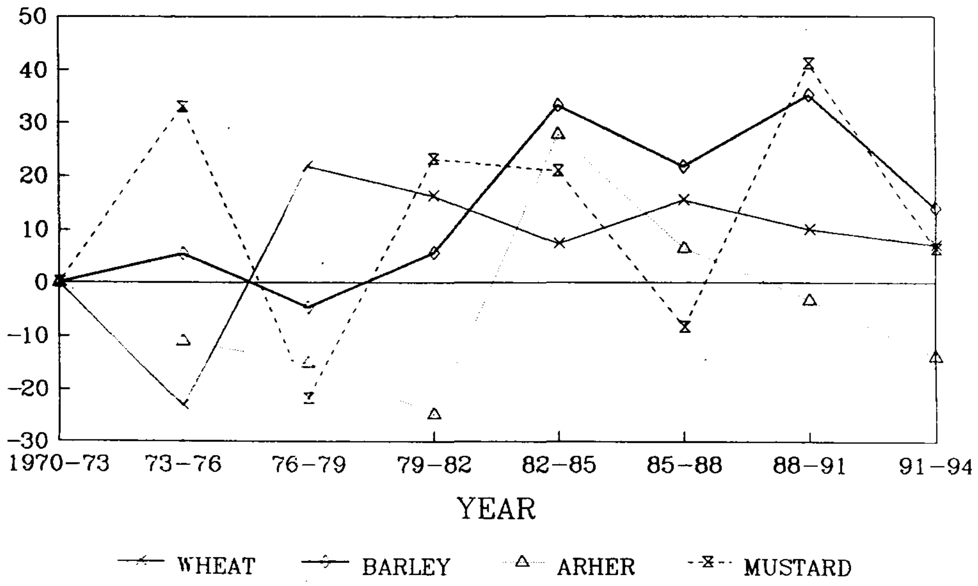
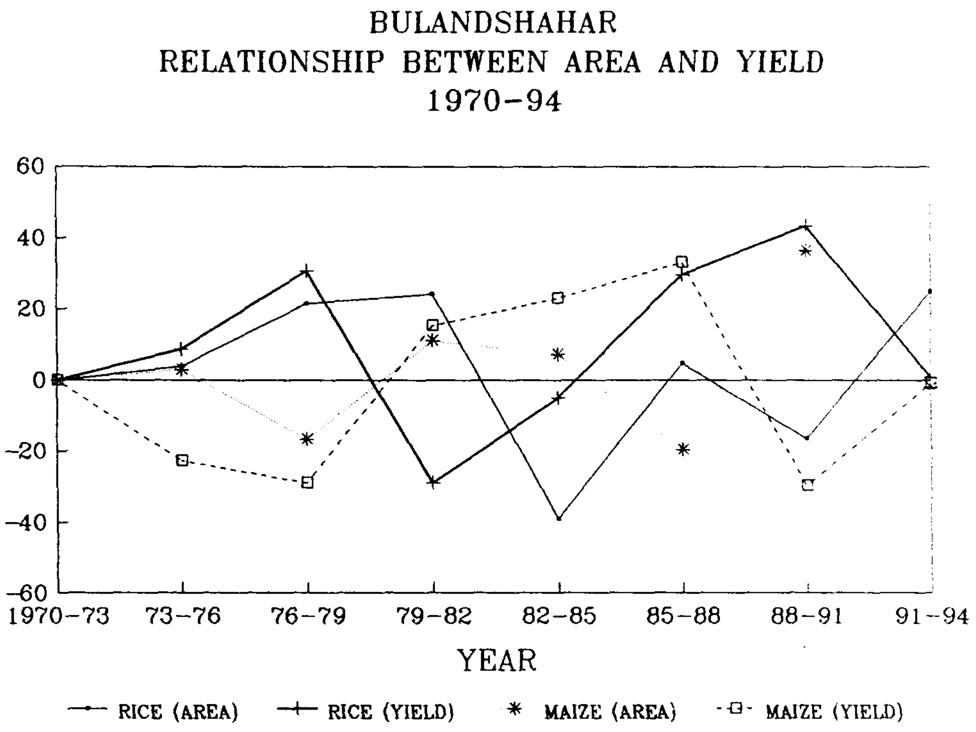


Fig. 3.15A,B


BULANDSHAHAR
RELATIONSHIP BETWEEN AREA AND YIELD
1970-94
60
40
20
0
-20
-40
-60
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
RICE (AREA)
RICE (YIELD)
MAIZE (AREA)
MAIZE (YIELD)

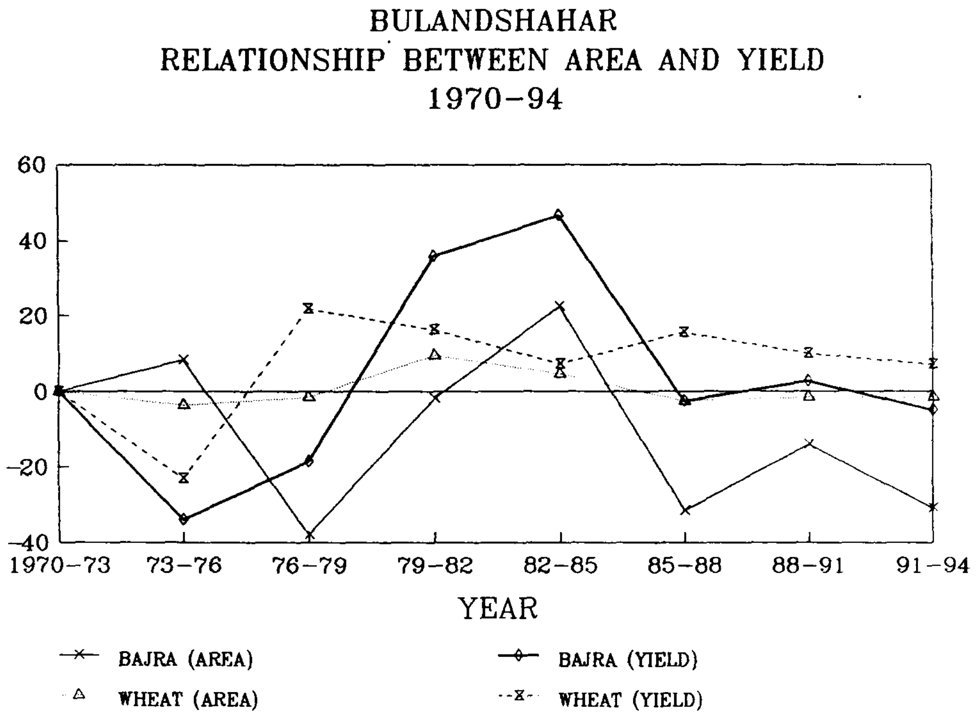
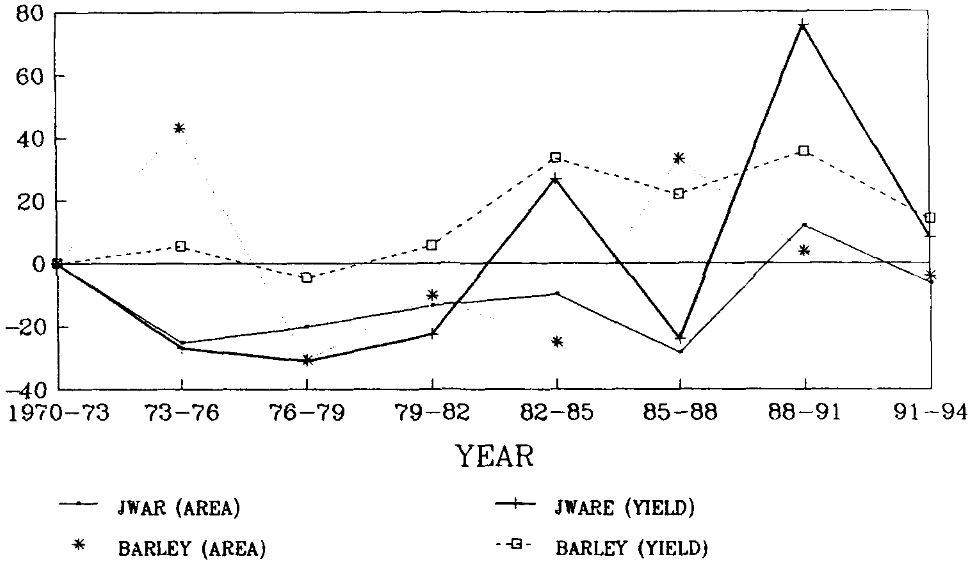

BULANDSHAHAR
RELATIONSHIP BETWEEN AREA AND YIELD
1970-94
60
40
20
0
-20
-40
1970-73
73-76
76-79
79-82
82-85
85-88
88-91
91-94
YEAR
BAJRA (AREA)
BAJRA (YIELD)
WHEAT (AREA)
WHEAT (YIELD)

Fig. 3.21 I,Il

BULANDSHAHAR
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94



BULANDSHAHAR
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94

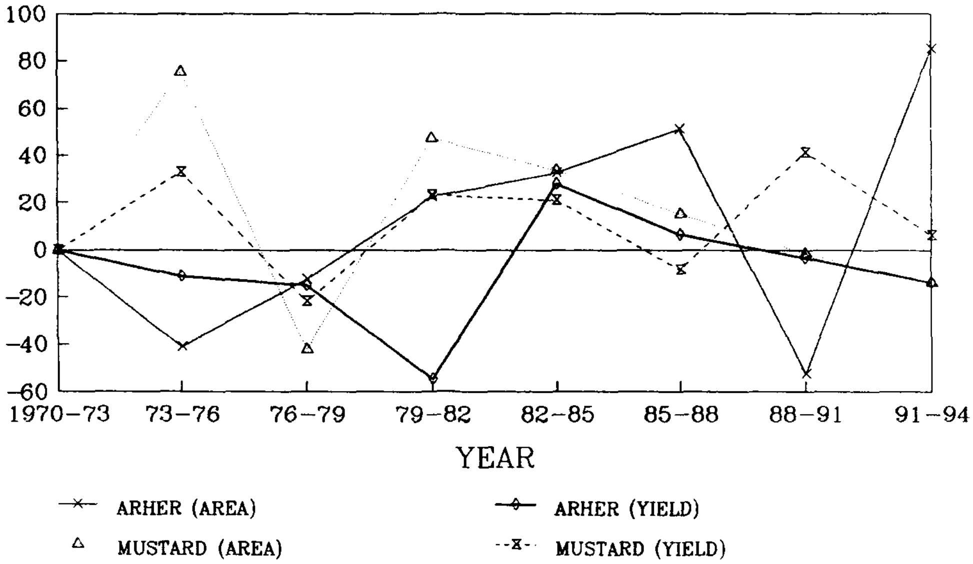


Fig. 3.21J,J1

GHAZIABAD
TREND OF YIELD OF DIFFERENT CROPS
1976-94

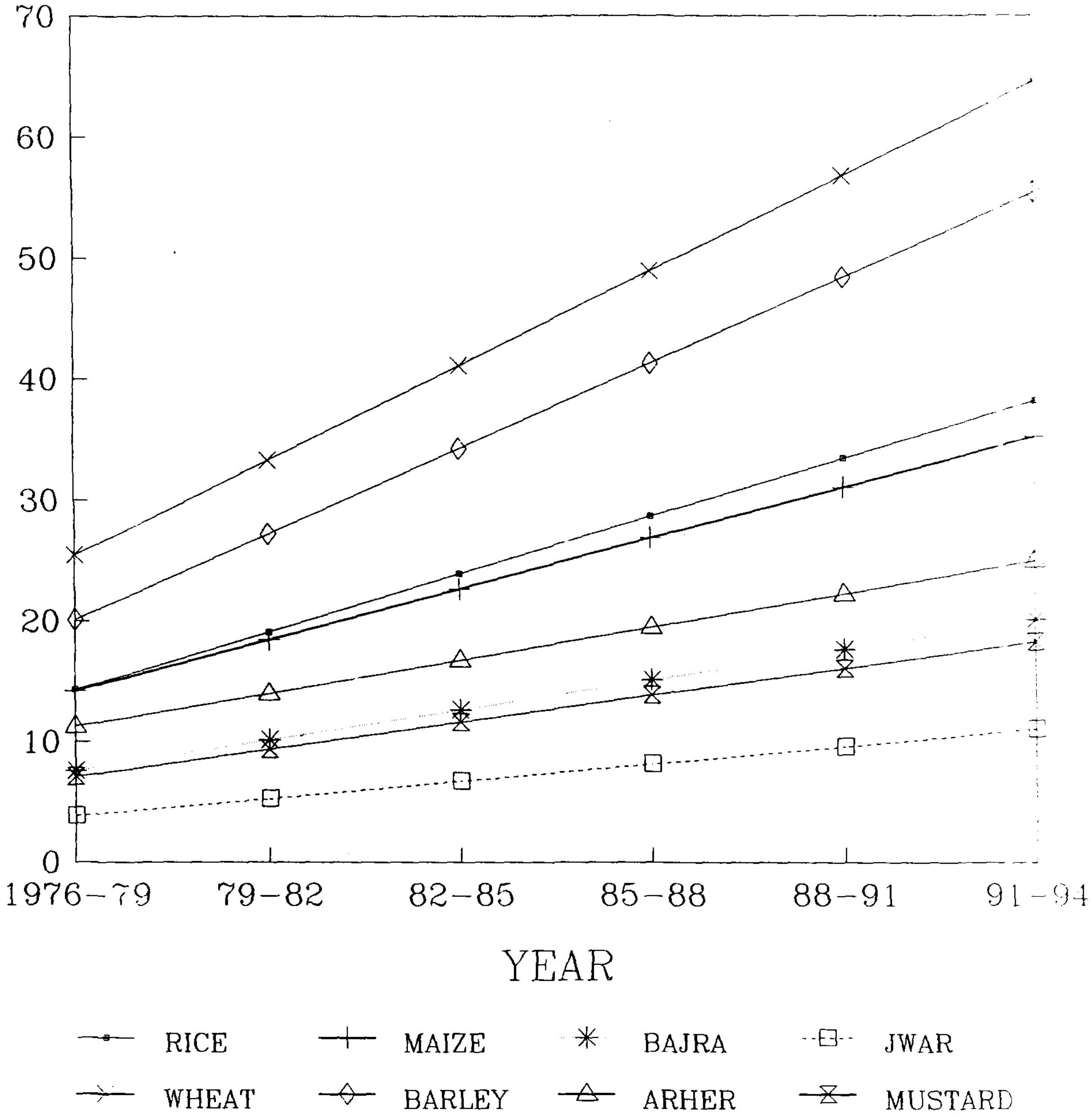
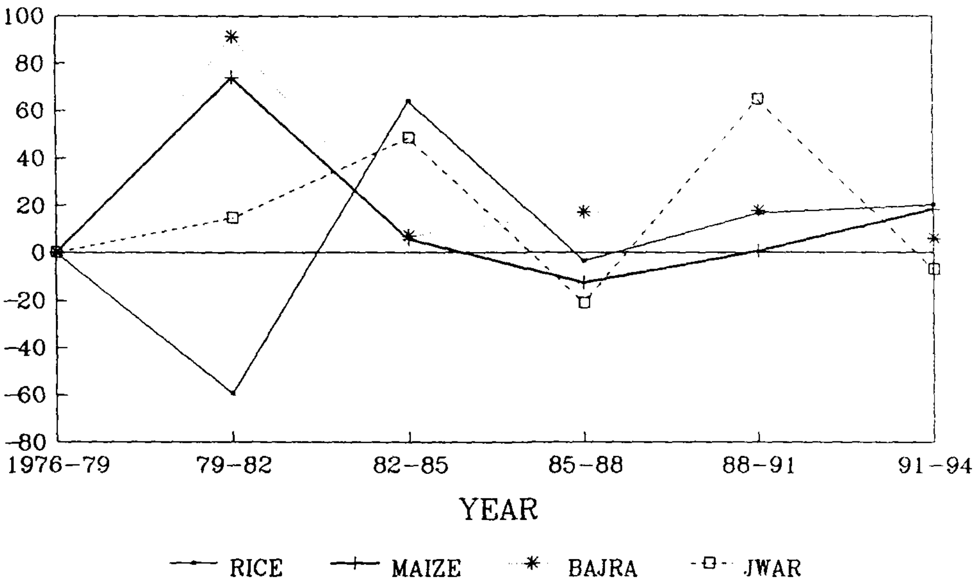


Fig. 3.16

GHAZIABAD
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
1976-94



GHAZIABAD
%AGE CHANGE OF YIELD OF DIFFERENT CROPS
1976-94

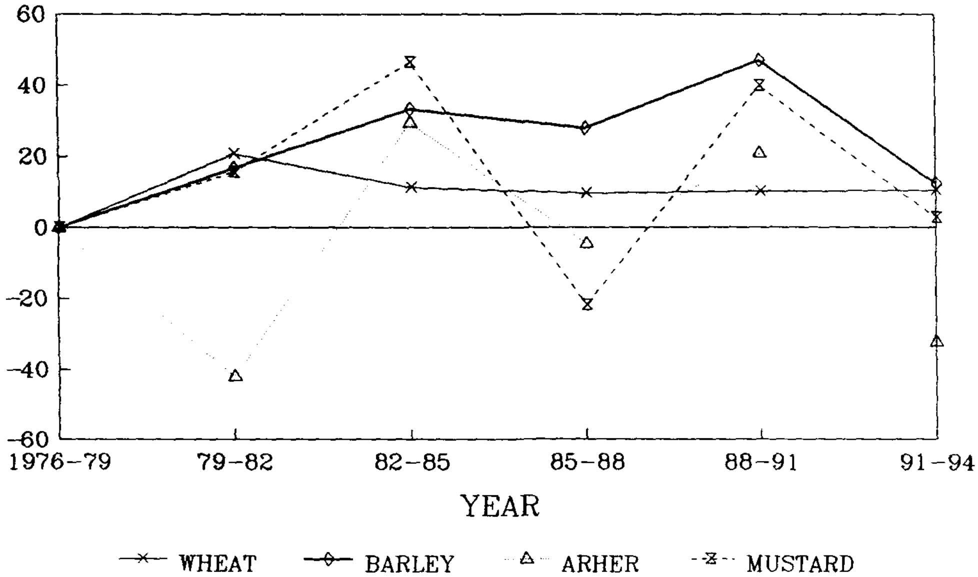
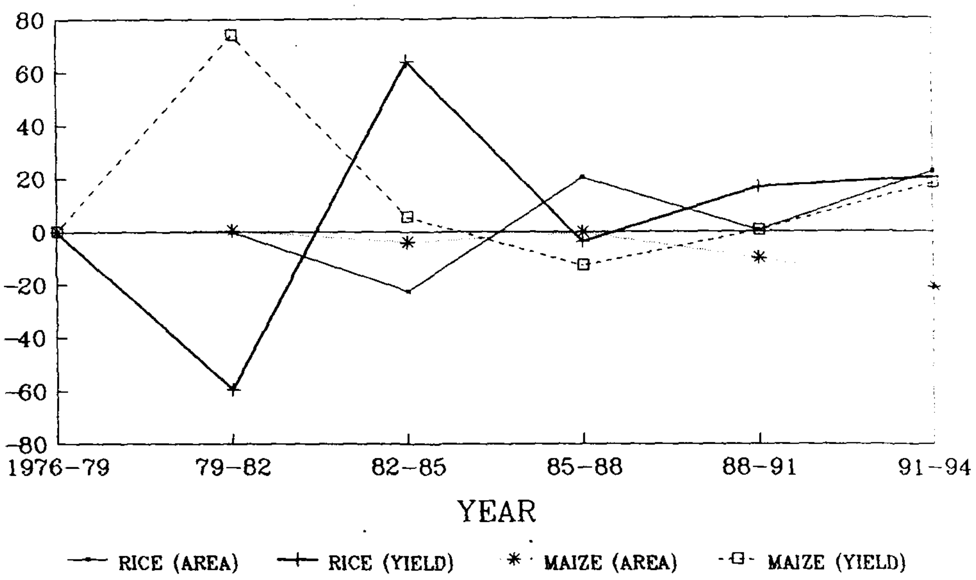


Fig. 3.16A,B

GHAZIABAD
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94



GHAZIABAD
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94

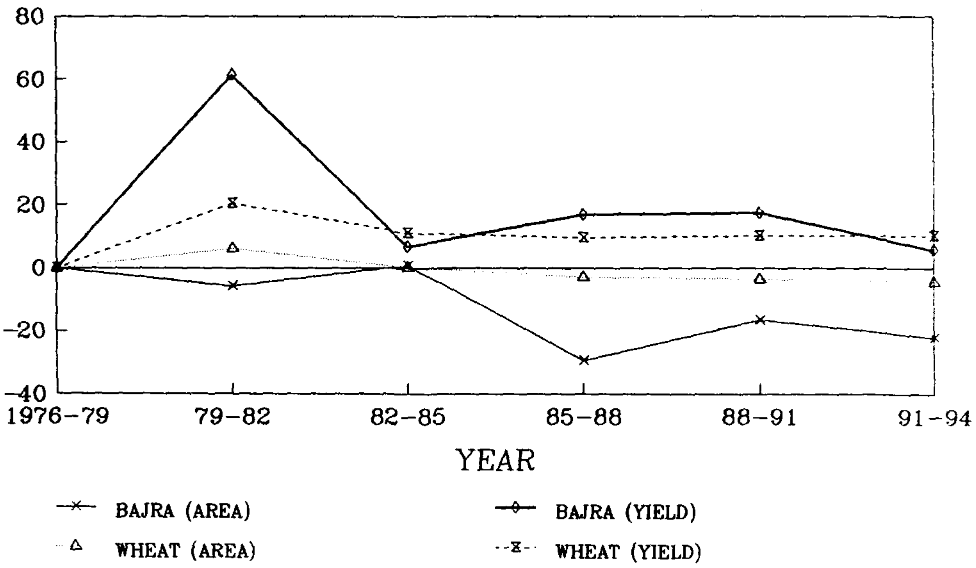
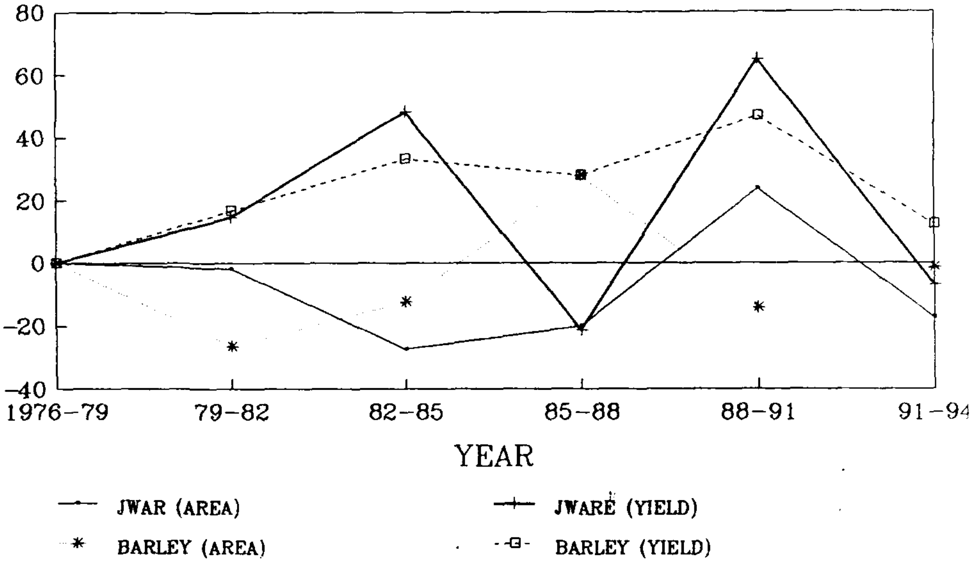


Fig. 3.21K,K1

GHAZIABAD
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94



GHAZIABAD
RELATIONSHIP BETWEEN AREA AND YIELD
1976-94

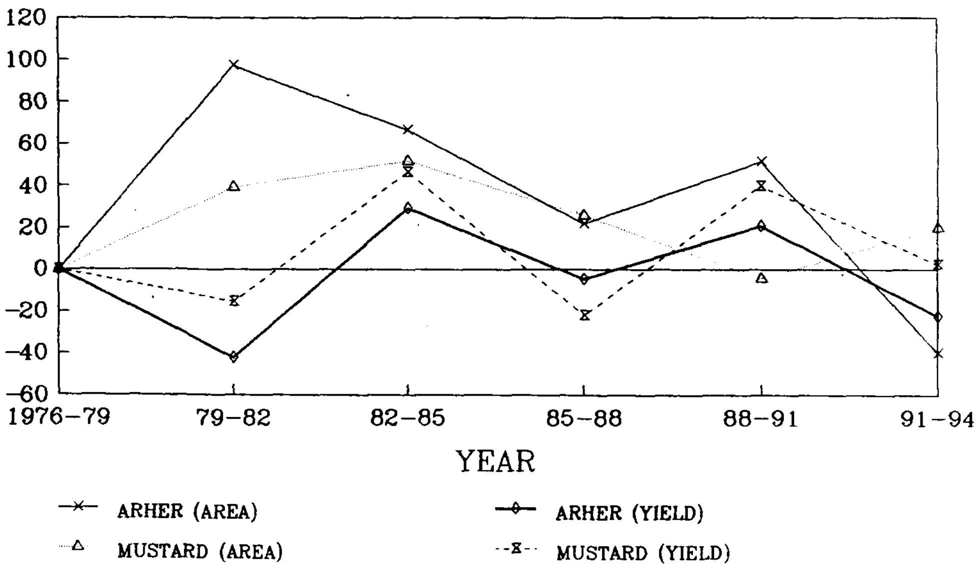


Fig. 3.21L,L1

trend of the selected crops. The growth of yield has increased at varying degree among all the crops except arhar which experienced negative growth inspite of increasing its area and productions. Jwar experienced highest growth followed by barley i.e., 6.23 times and 3.28 times respectively. One of the significant points is those five crops such as maize, bajra, jwar, wheat and barley experienced high yield of growth without increasing the area under these crops. It means the farmers are well aware about the impact of high yielding variety of seeds and other innovative packages. Besides these five crops and other four crops such as potato, sugarcane, mustard and rice exhibit the rising trend of yield, area and production.

After foregoing discussion about the trend of area, production and yield and relationship between them. It may be concluded that the rise in all three components is the main feature of post green revolution period. There has been a shift of area from coarse cereals to wheat, paddy and sugarcane. The production of these two crops grew rapidly with marked increase in yield level. However, the yield per hectare for all crops increased with the only exception of arhar, which indicates negative growth. It, therefore, implies the effect of area in the production and more pronouncing effect of new agricultural technology. The analysis of the production variability may be concluded that the infrastructure development of irrigation facilities is responsible for the adoptions of new package programs. The percentage of gross area increased from 34.89 to 73.69 percent in 1970-71 to 1993-94 respectively. About half of the irrigated area is shared by wheat followed by rice and sugarcane. Irrigation is necessary not only for the extension of the cultivated area but it also gives rise in the percentage share of area under double cropping. The means of irrigation have also changed tremendously from 1970-71 to 1992-93. The area under canal irrigation has declined from 42 to 26.98 percent in 1970-71 to 1992-93 respectively. While area irrigated by tube wells accounts for 43.60 percent, wells 13.65 percent and other sources 0.88 percent in 1970-71. In 1992-93 tube wells emerged to be the primary source contributing 70.87 percent of irrigated area. The share of canals, wells and other means declined to 26.98, 1.27 and 0.88 percent. The large scale introduction of electric pumps and oil engines are responsible for the increasing use of tube wells. This has consequently given rise to the consumption of fertilizer during the same period. The total fertilizer used in 1970-71 in Upper Ganga-Yamuna Doab found to be 33.03 kg per hectare. Which increased to 142.98 kg per hectare in 1993-94. It further reveals that the consumption of fertilizer kg per hectare in Upper Ganga-Yamuna Doab has increased more than four hundred percent from 1970-71 to 1992-93. The percentage of area under high yielding variety of seeds occupied hundred percent of gross cropped area. The study area has also witnessed remarkable rise in the number of agricultural implements particularly tractors, oil engines and electric pumps, which has been discussed earlier.

The above supporting information clearly reveal that the level of agricultural productivity improved mainly due to many fold increase in the modern agricultural implements and use of high yielding variety of seeds and fertilizers. At the same time, production fluctuated in the study area considerably due to inadequate rainfall and other environmental factors. The years of 1979-80, 1981-82, 1986-87, 1987-88, 1989-90 and 1991-92 have been, perhaps, the most difficult years when the output dropped significantly. This leads us to conclude that weather elements have still a bearing on the development of agriculture.

AGRICULTURAL PRODUCTIVITY

The term productivity can be interpreted in various ways and senses. Geographers and economists to define and elaborate the concept of agricultural productivity have made many attempts.

(Agricultural productivity may be defined as a function of interplay of the physical and cultural variables and it manifests itself through Rs. per hectare and total volume of production. Some economists suggested that the yield per acre should be considered to indicate agricultural productivity. Economists suggested that productivity could be measured in terms of per unit of labour and different regions compared on that basis.)

(After long discussion it was generally agreed that Rs per hectare may be considered to represent the agricultural productivity in a particular region, and that other factors of production be considered as the possible cause for the variation while comparing it with other regions.)

As there are many different concepts of productivity so, there are still more ways to compute it. The author has attempted to measure productivity in terms of Rs. per hectare because at present Rs. per hectare is the most fixed and permanent and will result oriented to measure the agricultural productivity in Upper Ganga-Yamuna Doab. Other measures of productivity have been omitted because other methods are somewhat complex, especially when the reliable data is not available in the required form.

(Agricultural productivity of an area is influenced by number of physical, socio-economic, institutional and organisational factors. It is a function of different factors including the physical (relief, climate, soil), socio-economic (size of operational holding, occupational holding, occupational structure of population, type of farming and land tenancy system. In fact the level of productivity as a concept means the degree to which the man made framework is able to exploit the physical resources of an area for maximising production.

Researchers from different disciplines such as economics, geography and agricultural sciences have long been engaged in determining the agricultural productivity in different parts of the world and have devised various methods to measure it. Almost all the measures suffer from one or the other defect. Thomson[1] (1926) while measuring the relative productivity of British and Danish farming emphasized and expressed it in terms of gross output of crops and livestock. Buch[2] (1937) in his study of Chinese agriculture increased agricultural efficiency by output expressed in terms of grain equivalent for various crops in relation to stable food. Ganguly[3] (1938) in study of Ganga Valley to find out agricultural productivity prepared an index of agricultural efficiency by multiplying the percentage of crop share with percentage of crops yield in an aerial unit and later averaging them into one. Kendall[4] (1939) used four coefficients namely productivity coefficient, ranking coefficient, money value coefficient and starch equivalent or energy coefficient. Hirsch[5] (1943) used 'Crop Yield Index' as the basis for productivity measurement. Zobel[6] (1950) attempted to determine the labour productivity as ratio of total output to productivity. Stamp[7] (1952) applied Kendall's ranking coefficient to find out agricultural productivity. Stamp[8] (1958) used another method, to convert total agricultural production in calories. Khusro[9] (1965) has assessed the productivity with the output per unit of single input and output per unit of cost of all inputs in the agricultural production. Shafi[10] (1965) has assessed the productivity on the basis of workers engaged in agriculture. Shafi[11] (1970) attempted to compute the index of productivity following on the formula initiated by Enyedi for each district of India with regard to 12 food crops.

However, in the present study Rs. per hectare has been used to measure the agricultural productivity tehsil wise in Upper Ganga-Yamuna Doab at a given point of time. The analysis is based on three years moving average from 1993 to 1995, and the point of time is taking 1994.

High Agricultural Productivity

High productivity areas characterized over seven tehsils namely Nakur, Muzaffarnagar, Jansath, Baghpat, Sardhana, Mavana and Meerut. These regions are having high productivity. These tehsils constitute a contiguous zone in the Upper Ganga-Yamuna Doab. High productivity is due to favourable geo-ecological conditions, especially the rich and well-drained soils, adequate water supply, relatively high amount of fertilizer consumption and progressive nature of farmers.

Medium Agricultural Productivity

This region comprises of six tehsils, namely Saharanpur, Kairana, Budhana, Hapur, Garhmukteshwar, and Bulandshahr. There are physical constraints like inundation, poverty of soils and poor drainage, which are hampering in the enhancement of agricultural productivity in these blocks.

Low Agricultural Productivity

This region includes the seven tehsils, namely Roorkee, Deoband, Ghaziabad, Dadri, Sikandrabad, Anoopshahr and Khurja. These tehsils of Upper Ganga-Yamuna Doab have low productivity due to the inadequate controlled irrigation, infertile soil and over all high pressure on agricultural land. The size of land holding is small in which mechanised farming is not possible. Besides the soils of these tehsils are sandy and clayey and overall economic backwardness of the farmers which have reduced their risk taking capacity for the adoption of new agricultural innovations (Table 3.16 and Figure 3.22).

Table 3.16

AGRICULTURAL PRODUCTIVITY

High Agricultural Productivity Rs/ Hectare		Medium Agricultural Productivity Rs/ Hectare		Low Agricultural Productivity Rs/ Hectare	
Name of Tehsils	**No. of Tehsils**	**Name of Tehsils**	**No. of Tehsils**	**Name of Tehsils**	**No. of Tehsils**
Nakur, Muzaffarnagar, Jansath, Baghpat, Sardhana, Mavana, Meerut	7	Saharanpur, Kairana, Budhana, Hapur, Garmukteshwar, Bulandshahr	6	Roorkee, Deoband, Ghaziabad, Dadri, Sikandrabad, Anoopshahr, Khurja	7

Source : Data obtained from the district headquarters.

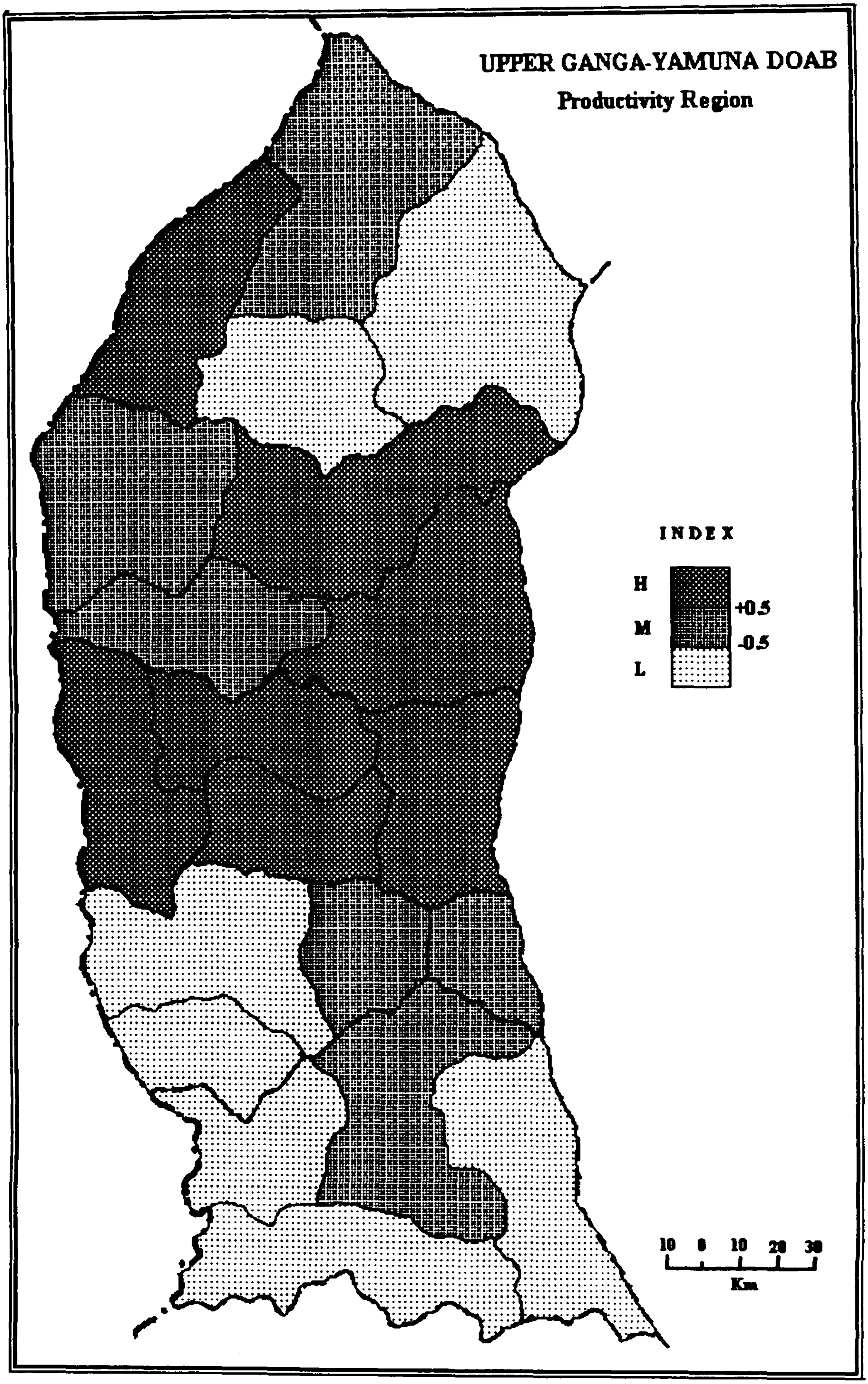

UPPER GANGA-YAMUNA DOAB
Productivity Region
INDEX
H
M
L
+0.5
-0.5
10 0 10 20 30
Km

Fig. 3.22

RANKING OF CROPS

Cropping structure of any area can be understood with the help of ranking of crops, which gives an insight in geographical reality. It provides plethora of informations regarding cropping structure, agricultural operations, periods of peak labour demand and the opportunities of employment to the farmers' families as well as dependant labourers. It also offers information regarding the nature of economy because ranking of crops show whether farming practices in a particular aerial unit are traditional subsistence type, commercial market oriented or partly subsistence and partly market oriented. Clear understanding of crop combination helps in planning at macro, meso or micro level region. In addition to it ranking of crops also indicates that, which crop is competing with each other to gain more hectage under their cultivation. After assessing the relative strength of different crops in geographical unit. The process of planning can be more rationally initiated for the optional use of the available land for cultivation. A judicious use of land infact can help in raising the agricultural production even from a less fertile area, and thus can be use full in reducing the inter-regional imbalances in agricultural sector of economy.

Fertility of soil, soil texture, structure and microelements of climate determine the cropping structure, cropping strength and crop concentration in a particular areal unit even at the field level. The socio-economic variables like the land holding, size of fields, irrigation facilities and availability of modern inputs also have a close bearing on the cropping mosaic. Nevertheless in developing nations like ours, the physical environment of a place plays a dominating role in decision making process about crops to be sown by the farmers. The development of infrastructural facilities like irrigation and power have however, enabled the farmers to overcome the problems of deficient rainfall winter season.

Crop rotation along with suitable crop combination can enhance the productivity to many folds irrespective of unfavourable agro-climatic settings. With suitable crop combination and crop rotations deterioration in soil fertility and, soil depletion may also be avoided. Unless the major crops of the region are studied in their ranking order and the areal strength of each crop is determined, appropriate associations of soils exhaustive and soil enriching crops for each situation can't be ascertained. For this purpose a comparison of areal strength of various crops in each of the areal units seems to be essential.

The first three leading crops in each tehsil of the Upper Ganga-Yamuna Doab have been ranked for the period between 1993 to 1995, and the result has been plotted in Figure.

First Ranking Crops

Sugarcane: Sugarcane ranks first in the different tehsils of five district of Upper Ganga-Yamuna Doab and has been plotted in Figure 3.23. Which reveals that sugarcane ranks first in tehsils of Nakur, Deoband, Kairana, Muzaffarnagar, Budhana, Jansath, Sardhana and Mavana.

The cultivation of sugarcane requires well drained alluvial soil with moisture rich inorganic matter. The crop requires about 100cm to 150cm of rainfall and it also requires 30^0C to 35^0C of temperature. The above said area is well suited for the sugarcane, because it enjoys all the conditions which sugarcane cultivation direly needed. Therefore, farmers living in these regions prefer sugarcane cultivation and associated activities on top priority.

Table 3.17

RANKING OF CROPS

FIRST RANKING CROPS			SECOND RANKING CROPS			THIRD RANKING CROPS		
NAME OF THE CROPS	**NAME OF TEHSILS**	**NO. OF THESILS**	**NAME OF THE CROPS**	**NAME OF TEHSILS**	**NO. OF THESILS**	**NAME OF THE CROPS**	**NAME OF TEHSILS**	**NAME OF THESILS**
Sugarcane	Nakur, Deoband, Muzaffarnagar, Kairana, Budhana, Jansath, Mavana, Sardhana	8	Sugarcane	Roorkee, Saharanpur, Nakur, Muzaffarnagar, Budhana, Sardhana, Meerut	7	Maize	Saharanpur, Baghpat, Sardhana, Garhmukteswar	4
Wheat	Anoopshahr, Khurja, Sikandrabad, Dadri, Bulandshahr, Hapur, Garhmukteswar, Ghaziabad, Meerut, Baghpat	10	Wheat	Deoband, Jansath, Kairana, Baghpat, Mavana	5	Rice	Roorkee, Nakur, Deoband, Kairana, Muzaffarnagar, Budhana, Jansath Mavana, Meerut	9
Rice	Saharanpur, Roorkee	2	Maize	Ghaziabad, Dadri, Sikandrabad, Khurja Bulandshahr, Anoopshahr	6	Sugarcane	Ghaziabad, Dadri, Hapur, Bulandshahr, Anoopshahr	5
			Rice	Hapur, Garhmukteswar	2	Barley	Sikandrabad, Khurja	2

Source : Data obtained from the district headquarters of the respective tehsils

Wheat: Wheat, the major cereal crop got first rank in several tehsils of Upper Ganga-Yamuna Doab. The tehsils in which it ranked first are Baghpat, Meerut, Ghaziabad, Hapur Dadri, Sikandrabad, Bulandshahr, Garhmukteshwar, Anupshahr and Khurja. For efficient cultivation of wheat the temperature should be uniformly high between 10^{0}C to 15^{0}C and 20^{0}C to 25^{0}C during the sowing and harvesting periods respectively. Rainfall should be between 25cm to 75cm. Irrigation can groom it even in deficient rainfall areas. Suitable soil is alluvial. Cheap labour supply is also of great importance. All these favourable conditions are available in the said tehsils, which help wheat to rank first among them.

Rice: Rice crop ranks first in the tehsils of Roorkee and Saharanpur of Saharanpur district in Upper Ganga-Yamuna Doab. The cultivation of rice needs high temperature and high humidity, ranges from 30^{0}C to 35^{0}C temperature and 100 to 150cm rainfall. These areas are suited for the cultivation of rice, though the rainfall does not occur beyond 65 to 70cm. Yet the cultivation is done through assured irrigation. Clay and clayey loam are suitable for cultivation. Such soils are capable of holding water for longer period. It is also grown on alluvial, red and lateritic soils (Table 3.17 Figure 3.23).

Second Ranking Crops

Sugarcane: Sugarcane as a second ranking crop found in the tehsils of Roorkee, Saharanpur, Nakur, Muzaffarnagar, Budhana, Sardhana and Meerut. The favourable geographical conditions for the growth of sugarcane requires that the temperature should be between 30^{0}C to 35^{0}C, short cool dry winter season during ripening and harvesting periods. During the life cycle of sugarcane about 100cm to 150cm of rainfall is required. Deep rich loamy soils and black

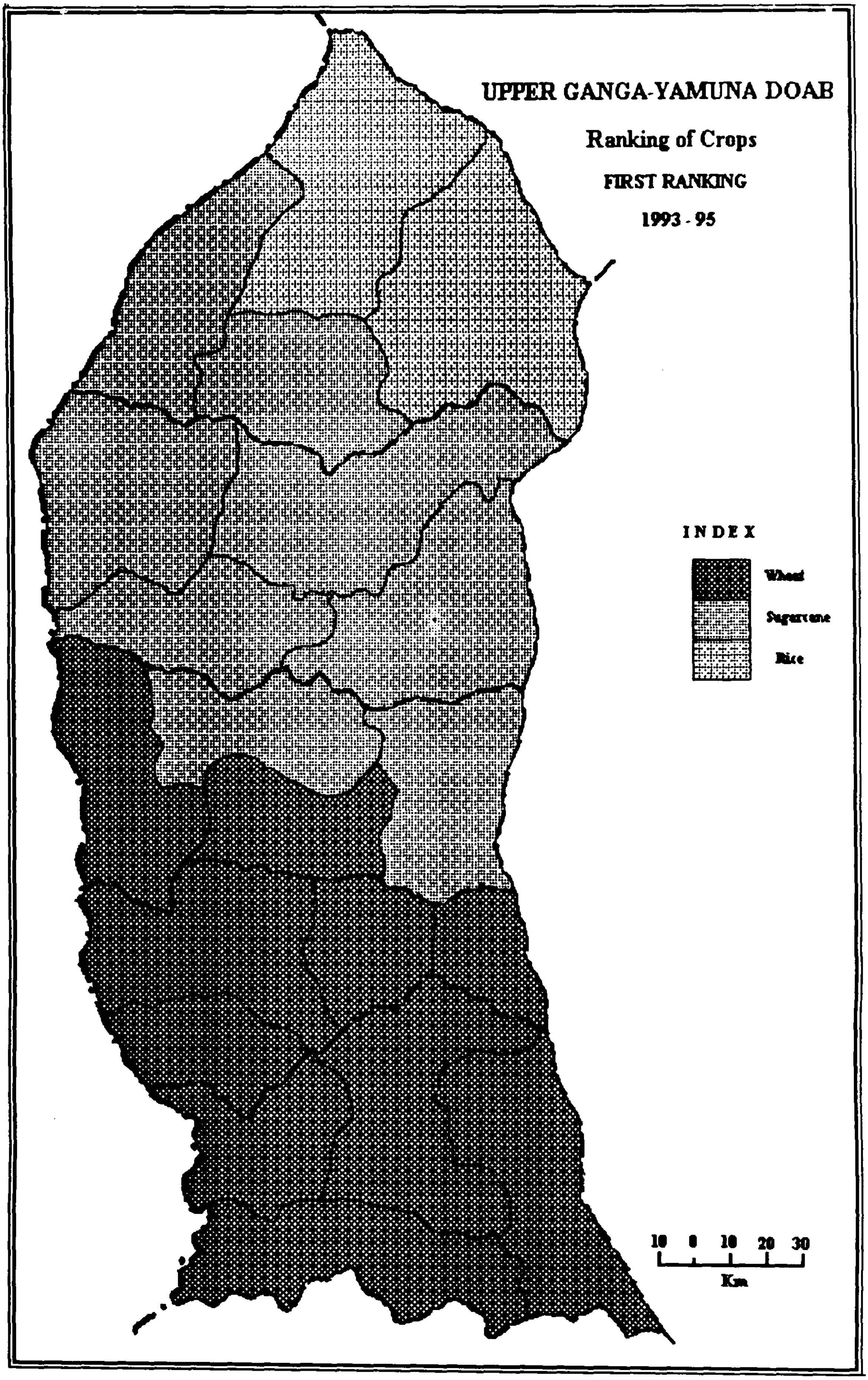

UPPER GANGA-YAMUNA DOAB
Ranking of Crops
FIRST RANKING
1993 - 95
INDEX
Wheat
Sugarcane
Rice
10 0 10 20 30
Km

Fig. 3.23

soils are good, abundant labour is helpful in the cultivation of sugarcane.

Wheat: Wheat got second rank in the Upper Ganga-Yamuna Doab in the tehsils of Deoband, Jansath, Kairana, Baghpat, Mavana. For good harvest of wheat the temperature 15°C to 25°C are suitable. Rainfall should be moderate between 25cm to 75cm. The alluvial soil with loamy character is suited for cultivation.

Maize: Comes to second ranking crop which covers the tehsils of Ghaziabad, Dadri, Sikandrabad, Bulandshahr, Khurja and Anoopshahr. The cultivation of maize requires well drained sandy loams with rich organic matters. It requires 50cm to 100cm of rainfall. It also requires about 25°C to 30°C of temperature and dry weather.

Rice: Rice ranks second in tehsils of Hapur and Garhmukteshwar. The conditions, which favour the growth of rice, are well drained loamy and alluvial soil with organic matters. The crop needs 100cm. to 150cm. of rainfall and temperature in between 30°C to 35°C (Figure 3.24 and Table 3.17).

Third Ranking Crops

Maize: Maize comes to third ranking crops in tehsils of Baghpat, Sardhana and Garhmukteshwar of the study area. Maize requires 25°C to 30°C temperature with dry weather. The cultivation needs well drained sandy loam, rich in organic matter. The amount of rainfall should be between 50cm to 100cm with well distributed during growing period.

Rice: Rice crop ranked third in tehsils of Roorkee, Nakur, Deoband, Kairana, Muzaffarnagar, Budhana, Jansath, Mavana and Meerut. These tehsils are not contiguous and are well scattered in the region.

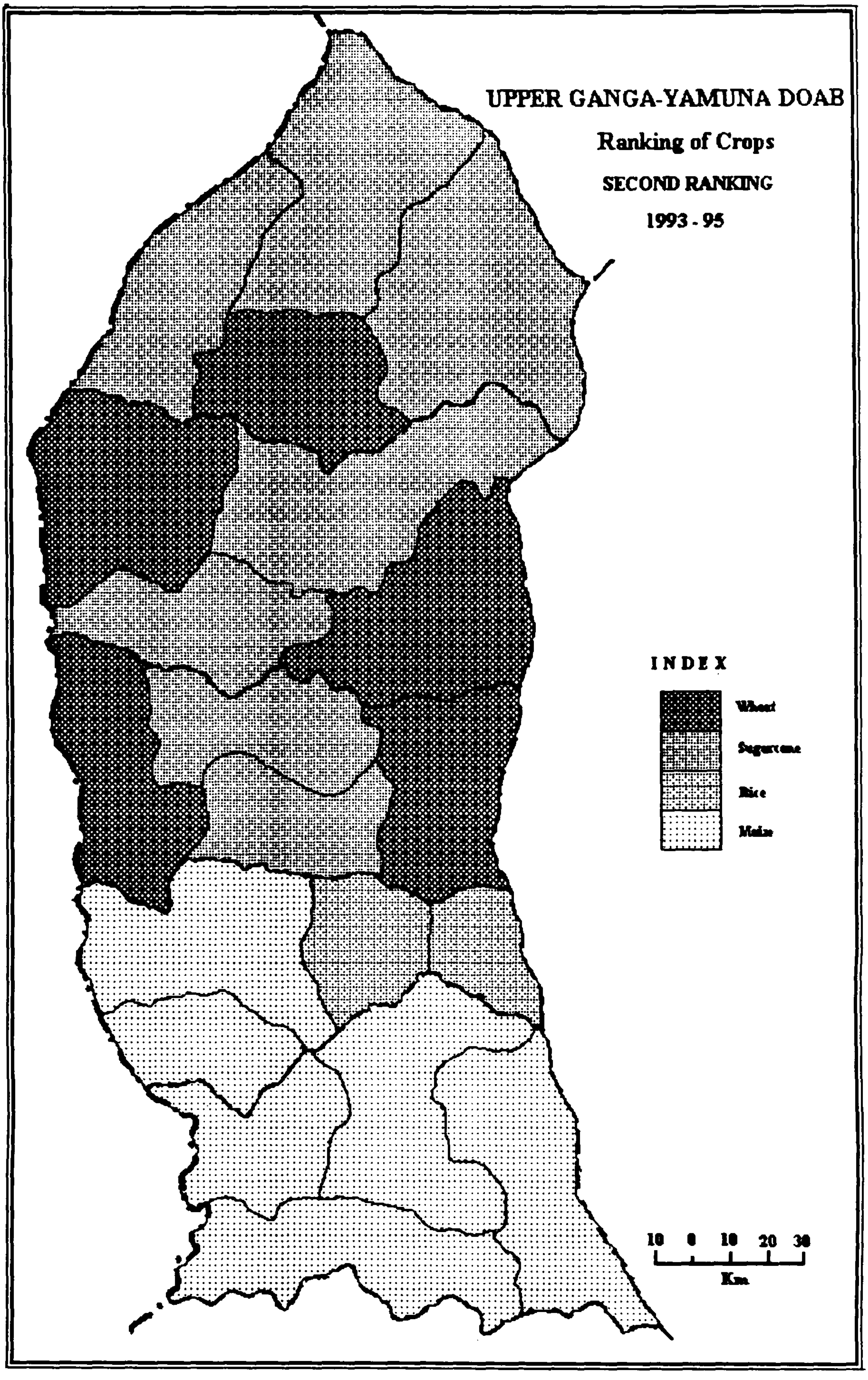
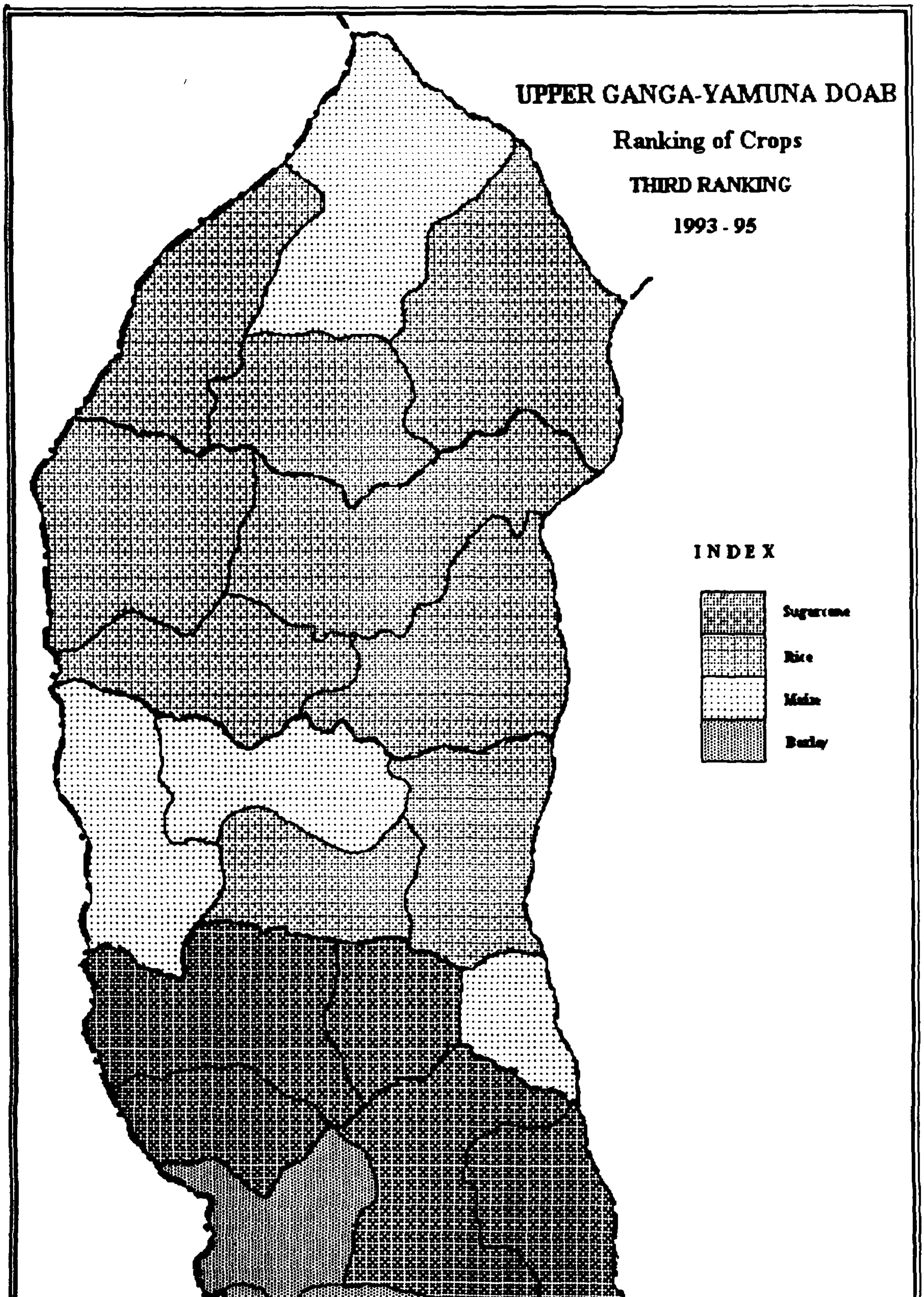

UPPER GANGA-YAMUNA DOAB
Ranking of Crops
SECOND RANKING
1993 - 95
INDEX
Wheat
Sugarcane
Rice
Maize
10 0 10 20 30
Km

Fig. 3.24

Sugarcane: Sugarcane ranked third in the tehsils of Ghaziabad, Dadri, Hapur, Bulandshahr and Anoopshahr.

Barley: Barley is the third ranking crop found in the tehsils of Sikandrabad and Khurja. The cultivation of Barley requires well drained loamy to sandy loamy soils. It requires 75 to 100cm. rainfall and $30^{0}C$ to $35^{0}C$ of temperature and cool dry weather at the time of ripening. All the favourable conditions are found in the study area were barley has got the third ranking crops (Figure 3.25 and Table 3.17).



UPPER GANGA-YAMUNA DOAB
Ranking of Crops
THIRD RANKING
1993 - 95
INDEX
Sugarcane
Rice
Maize
Barley
10 0 10 20 30
Km

Fig. 3.25

CROP COMBINATION

Comprehensive understanding of the crop combination of region provides a scientific basis for agricultural regionalisation. No crop is grown in isolation from other crops in a given areal unit at a given point of time, however crops are grown in combination. Crop combination is of great significance for regionalisation of the agricultural development.

The present study focuses upon the analysis of crop combination in Upper Ganga-Yamuna Doab with keeping in mind of following objectives; First, to find out the set of those crops which are dominating in economy of each tehsil of the Upper Ganga-Yamuna Doab; second, to explore into the patterns and changes in crop combination; and finally, to make sure whether agriculture in Upper Ganga-Yamuna Doab is becoming market oriented.

Various geographers and social scientists to outline the crop combinations in different parts of the world have used a number of statistical techniques. Some geographers and social scientists have adopted the Weaver's Minimum Deviation Method, while others have opted other methods like that of S·M·Rafiullah.

In the present analysis the principles of Weaver technique regarding the calculation of crop combination region has been used. In his work Weaver calculated deviation from the real percentage of crops for all possible combinations in the components aerial units against a theoretical standard. The theoretical curve for the standard measurement was employed as given below:

Monoculture	100 percent of the total harvested crop land in one crop.
2 Crop Combination	50 percent in each of two crops.

3 Crop Combination 33.3 percent in each of three crops.

4 Crop Combination 25 percent in each of four crops.

5 Crop Combination 20 percent in each of five crops and systematically through to for the determination of the Minimum Deviation. The Standard Deviation Method is given below.

$$SD = \sqrt{\frac{\sum d^2}{n}}$$

Where 'd' is the difference between actual crop percentages in given aerial unit and the appropriate percentages in theoretical curve and 'n' is the number of crops in a given combination. As Weaver pointed out the relative values and not absolute values being significant square roots were not extracted. So that actual formula was used as follows: $d = \frac{d^2}{n}$

Weaver's method results into suitable and accurate grouping of crops.

Crop Combination Regions

Crop combination region based on Weaver's Method worked out for the year 1993-95 is given in Table3.18 and plotted in Figure 3.26. It may be concluded that there are three, four, and five crops combination in Upper Ganga-Yamuna Doab. In all six crops are involved in combination are sugarcane, wheat, rice, maize, pulses and barley.

Three Crop Combination Regions

Three crop combination areas are well distributed in Upper Ganga-Yamuna Doab and comprise of thirteen tehsils respective of their climatic and pedological conditions. The constituent crops however vary from place to place due to variation in temperature

Table 3.18

CROP COMBINATION REGIONS

THREE CROP COMBINATION			FOUR CROP COMBINATION			FIVE CROP COMBINATION		
INDEX	NAME OF TEHSILS	NO. OF TEHSILS	INDEX	NAME OF TEHSILS	NO. OF TEHSILS	INDEX	NAME OF TEHSILS	NO. OF TEHSILS
SWR	Roorkee, Kairana, Jansath, Sardhana, Muzaffarnagar	5	WSRP	Saharanpur	1	WMPVR	Dadri	1
SWM	Budhana, Baghpat, Mavana, Meerut, Garhmukteshwar	5	WRSP	Nakur	1	WMPBS	Khurja	1
WSM	Ghaziabad	1	SWRP	Deoband	1			
WMP	Sikandrabad	1	WMSP	Anoopshahr	1			
WMS	Bulandshahr	1	WSMP	Hapur	1			

Note : S : Sugarcane, W : Wheat, R : Rice, M : Maize, P : Pulses, B : Barley.

Source : Data obtained from the district headquarters of respective tehsils.

Table 3.18

CROP COMBINATION REGIONS

THREE CROP COMBINATION			FOUR CROP COMBINATION			FIVE CROP COMBINATION		
INDEX	NAME OF TEHSILS	NO. OF TEHSILS	INDEX	NAME OF TEHSILS	NO. OF TEHSILS	INDEX	NAME OF TEHSILS	NO. OF TEHSILS
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SWM	Budhana, Baghpat, Mavana, Meerut, Garhmukteshwar	5	WRSP	Nakur	1	WMPBS	Khurja	1
WSM	Ghaziabad	1	SWRP	Deoband	1			
WMP	Sikandrabad	1	WMSP	Anoopshahr	1			
WMS	Bulandshahr	1	WSMP	Hapur	1			

Note : S : Sugarcane, W : Wheat, R : Rice, M : Maize, P : Pulses, B : Barley.

Source : Data obtained from the district headquarters of respective tehsils.

and moisture conditions. Sugarcane, wheat and maize are major crops of three crop combination region and is found in Budhana, Baghpat, Mawana, Meerut and Garhmukteshwar. Other combination includes sugarcane, wheat and rice is found in Roorkee, Kairana, Muzaffarnagar, Jansath and Sardhana is due to the fact that these tehsils have very fertile soils. It has been observed that the farmers of these tehsils are very innovative and progressive in the adoption of new technology.

This region has well developed canal, networks, tube wells and roads. Agriculturally in these tehsils are well developed and farmers are paying more attention to the cultivation of sugarcane, wheat and rice. Wheat, sugarcane, maize combination is next in importance. This combination is found in the tehsil of Ghaziabad. Wheat, maize pulses form a three crop combination in Sikandrabad. Wheat, maize and sugarcane association is found only in Bulandshahr.

Thus it may be concluded that the farmers are now specialising in a few number of crops and devoting their most of arable land to one important crop in each of the rabi and kharif seasons. It is clear that subsistence traditional agriculture of the region is in the process of being transformed into market oriented semi-commercialised agriculture. Cultivators are not growing crops for family requirements but they have gone for the optimisation of their agricultural income. Infact increased agricultural income has improved and raised the standard of living of farmers, but at the same time many of the traditional institutions like that of mutual co-operations are being vanished. Consequently, large-size farmers have become more selfish and have increased their agricultural assets to significant extent. This trend has widened the gap of income in rural areas and had created many socio-economic problems.

Four Crop Combination Regions

Out of twenty tehsils, five tehsils were found to be under cultivation of four crops in Upper Ganga-Yamuna Doab. Areas of four crops combination dominate in the region are also widespread. The main crops involved in combination are sugarcane, wheat, rice, pulses, maize and barley. Wheat, sugarcane, rice and pulses the major association of crops is found in Saharanpur. It has enjoyed fertile alluvium soil and adequate irrigation and other infrastructure facilities, which led down the farmers to concentrate for the cultivation of more valuable crops, which are considered to be more remunerative. Wheat, rice, sugarcane, pulses association is next in importance, found in Nakur tehsil of Saharanpur district. The soil of these tehsils are alluvial in character varies from sandy to clayey loam and average annual rainfall 70cm. with sunny weather for most part of region provides appropriate conditions of growing in rabi and kharif crops. Sugarcane, wheat, rice and pulses constitute the crop combination in Deoband tehsil of Saharanpur district. Wheat, sugarcane, maize, pulses combination is found only in Hapur tehsil of Meerut district. Wheat maize, sugarcane, pulses combination is found in Anupshahr tehsil of Bulandshahr district.

If high yielding varieties of these crops could be developed sugarcane growing areas may have a more scientific rotation of crops and the agricultural efficiency may go up appreciably.

Five Crop Combination Regions

Areas with five crop combination in Upper Ganga-Yamuna Doab are few and widely scattered. Five crops combination is found in two tehsils of the region. Wheat, maize, pulses, barley and rice is the most important crop combination of Dadri tehsil of Ghaziabad. This region is having well developed infrastructure and the farmers are receptive to new ideas. The farmers are emphasizing on namely sugarcane, rice and wheat crop cultivation. Wheat, maize, pulses, barley and sugarcane are the five major crops that enter into combination in Khurja tehsil of Bulandshahr district. The average annual rainfall in these tehsils is about 75cm with sunny weather. The canals provide assured irrigation for cultivation of crops like wheat, sugarcane and rice. Moreover, irrespective of size of farms farmers have installed tubewells or pumping sets in their fields (Table 3.18 and Figure 3.26).

From the table it is cleared that sugarcane is the most important crop among all the crops growing in Upper Ganga-Yamuna Doab. It enters into combination with the other crops in all the tehsils with exception of Sikandrabad tehsil of Bulandshahr district. The million farmers under prevailing physico social conditions prefer to devote their arable lands to several crops. The high diversification of crops is based on the assumption of perfect certainty. Relaxation of this assumption may have considerable bearing upon the decision making of the farmers. Generally the farmers of most of the tehsils are interested in cultivation of sugarcane, wheat and rice which shows that agricultural economy in the region is mainly market oriented.

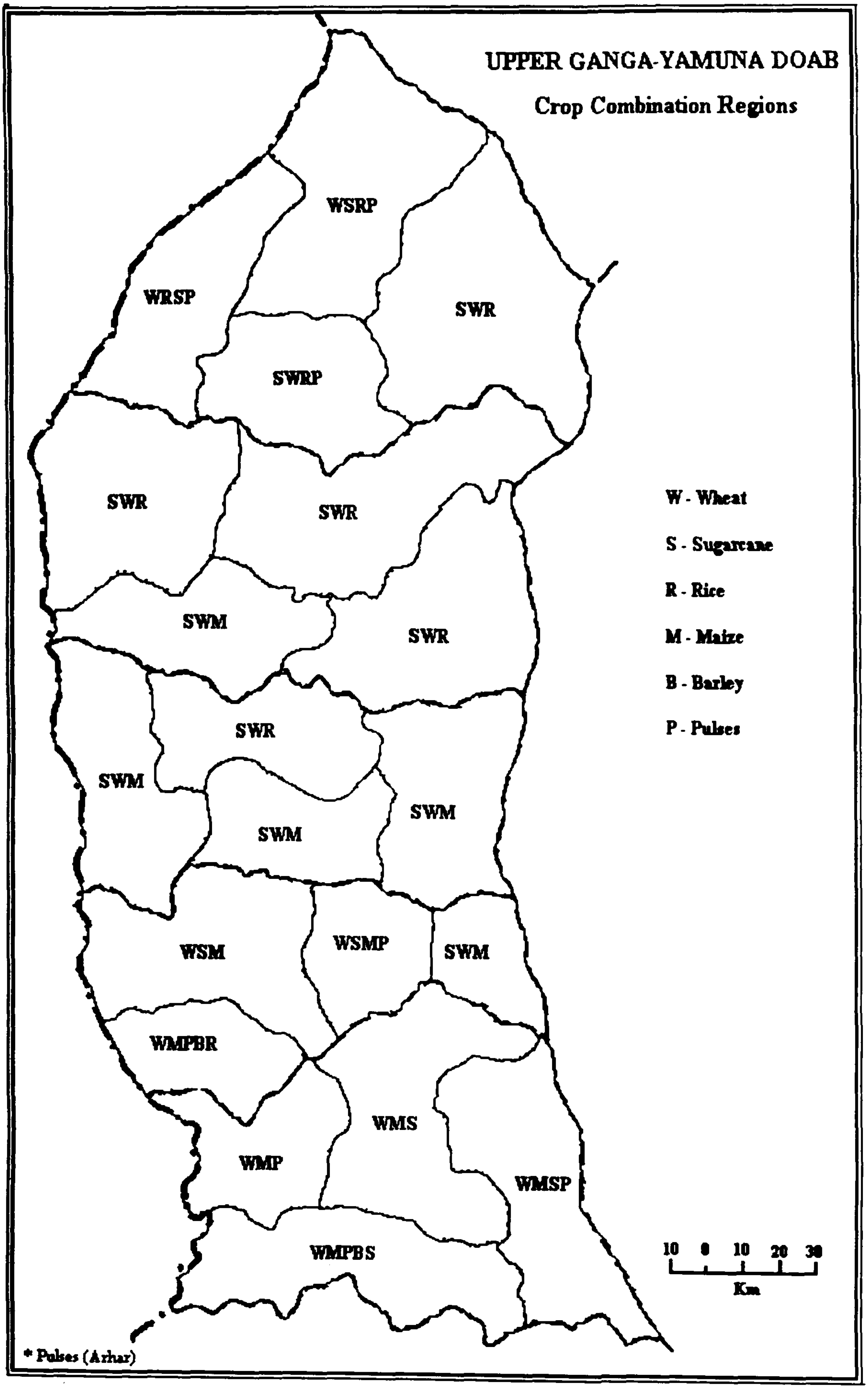
UPPER GANGA-YAMUNA DOAB
Crop Combination Regions
WSRP
WRSP
SWR
SWRP
SWR
SWR
SWM
SWR
SWR
SWM
SWM
SWM
WSM
WSMP
SWM
WMPBR
WMS
WMP
WMSP
WMPBS
W - Wheat
S - Sugarcane
R - Rice
M - Maize
B - Barley
P - Pulses
10 0 10 20 30
Km
* Pulses (Arhar)

Fig. 3.26

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CHAPTER IV

TREND OF DIFFUSION OF AGRICULTURAL INNOVATIONS

TREND OF DIFFUSION OF AGRICULTURAL INNOVATIONS

FACTORS OF DIFFUSION OF INNOVATIONS

Size of Land Holdings

Size of land holdings owned or operated by a farmer has positive relationship with adoption behaviour. Owners and operators of large sized farms have the economic resources, and can afford to take the risk involved in trying out a new idea or practice i.e., innovation. Many agricultural innovations require substantial economic resources and a relatively large sized operation for their adoption and use. Farmers operating small holding often lack the resources needed to use many of the innovations, which keep them away from adopting these practices.

Tenure Status

Relationship between the tenure status of farmers and their adoption behaviour found to be positive. The farmers who own their holdings wholly adopt a larger number of practices than part-owners or share-croppers can be explained by the fact that they can take the decision regarding the adoption of innovations by themselves. They also generally have the resources and motivation to adopt improved farming practices.

Income and Economic Status

Income is the most important indicator of the economic status of a farmers. Study reveals that relationship between the two variables found to be positively related with the level of adoption of agricultural practices. The economic status and adoption behaviour of farmers have a two-way relationship. Farmers with higher economic status adopt agricultural innovations, which lead to increase in their income. The increased income make more capital available to them for further investment in new ideas and practices i.e., innovations.

Non-adopters and later-adopters become poorer in relation to earlier adopters of high economic status because of their unwillingness to adopt innovations. It would be erroneous, however to conclude from this that the adoption behaviour is influenced by economic factors alone, but extra economic factors have important influence on farmers' adoption behaviour.

Availability of Irrigation

Relationship between the availability of irrigation and adoption behaviour dealt with the adoption of high yielding varieties. In all instances availability of irrigation found to be positively related to adoption behaviour in present study. The profitability of cultivating the high yielding varieties act as a powerful incentive for all varieties of farmers to adopt them. The availability of irrigation often acts as the most important pre-requisite for the adoption of high-yielding varieties.

Commercial Orientation

Farmers who primarily sell their produce in the market have commercial orientation to farming and their goal is to increase their production at a lower cost so that they can compete and make a profit. These farmers are more receptive to innovation than farmers with a subsistence orientation to farming who primarily consume rather than to sell their produce in the market. Hence, there is a positive relationship between commercial orientation and adoption.

Caste Status

Caste constitutes one of the most fundamental structural features of the Indian society. The overlap between caste and tenure status categories is clearly evident in Indian society. The close correspondence between caste and tenure status not only affects the nature of agricultural activities in Indian villages but also the adoption behaviour of farmers. The level of adoption of farmers increases with increasing caste status. However, in some areas the level of adoption found to be high among farmers belonging to castes of intermediate status to which farming was traditional caste occupation than among farmers who belonged to caste of higher ritual status. So, relationship between caste status and adoption behaviour can't be explained away in economic terms.

Social Participation

Social participation is generally measured in terms of his membership, holding of office and attendance in meeting of formal organisations in a place. Participation in social and organisational activities is expected to have an indirect influence on the adoption behaviour of farmers. It links the individual to the larger society and expresses him to variety of ideas. This exposure makes him positively predisposed towards innovative ideas and practices.

Urban and Outside contact

Exposure to a wide variety of ideas and information obtained through this outside contact makes the farmer progressive in outlook and 'cosmopolite' in orientation, which is, defined as "the degree to which an individuals orientation is external to a particular system". Farmers with cosmopolite orientation, as opposed to those with 'localistic' orientation travel widely, and are interested in the affairs beyond the boundaries of their villages. The cosmopolite orientation leads to a positive predisposition towards new ideas and practices.

Extension Contact

Extension contact has a direct influence on the adoption behaviour of farmers. The greater the degree of contact of farmers with extension personal, the greater the possibilities of farmers being influenced to adopt agricultural innovations.

Socio-Economic Status

Socio-economic status is a composite measure of several social and economic characteristics of farmers. Socio-economic status includes, caste, education, tenure status, size of farm owned, acres of land operated and a variety of material items owned including a house, furniture, radio and bicycle etc.. Farmers with higher socio-economic status tend to adopt new ideas and practices early and they are adopters as compared to farmers with low socio-economic status, who are either late adopters or non-adopters. Hence, socio-economic status and adoption of innovations positively related to each other.

The Mass Media

The use of mass media by Indian farmers is not as extensive as those of the developed countries. Their use as a source of information is mostly confined among a small group of educated, affluent and innovative farmers at the awareness and interest stages of the adoption process. The vast majority of Indian farmers rely primarily on interpersonal sources of information of both the institutional and non-institutional types.

The low level of literacy and formal education may be a barrier to the use of such non-print media as radio, television and film as long as farmers have access to them. Mass media is one of the most important factors in the diffusion of innovations.

TREND OF DIFFUSION OF AGRICULTURAL INNOVATIONS

For the development of society in any region, there is a great need for innovation diffusion and adoption of improved ideas and practices in almost all the fields of human activity. It is more so in the developing countries, because technological change and diffusion of innovations could bring about speedy and intensive change in the economic and social life of the people. In the development of Indian agriculture speedy and extensive introduction of technological change is one of the crucial factors. The technological change consists of adoption of farming technique such as use of fertilizer, pesticides and fungicides, improved variety of seeds, modern agricultural implements, improved irrigation facilities and soil and moisture conservation techniques. They are developed through intensive researches to bring about a drasting change in agricultural output and diversification's of cropping patterns for greater economic return to the farmers.

However, in the recent past food production in India has increased to a considerable extent and she has not only become self sufficient in food grains, but also has some better stock as well. This growth in agriculture has been possible because of certain degree of technological change and adoption of agricultural innovations. In facts the technological change in agriculture has been brought out through intensive research for the development of agriculture that subsequently brings greater benefits to the farmers.

The diffusion of innovation is a process in course of which those who have not adopted earlier adopt an innovation. Considerable time elapses before in a new technological development is accepted by cultivator, as he is to be conversed of its utility, he should know, to introduce it, and finally he should also be in a position to bear the risk involved in the adoptions of innovations in the beginning. The adoption process is, therefore, not simple as it involves several considerations. It is a process consisting of learning, deciding and acting over a period of time. It is not a result of a single decision but a series of action and thought processes, which could broadly be grouped in five stages. Firstly, the awareness in which the adopter gets initial knowledge about the innovations; secondary, the interest in which it takes ideas and information leading to acceptance of practice as a good idea for most of the farmers; thirdly, the education stage in which he decides that the innovation is worth while for ones own farms; fourthly, the trial stage (adoption on trial basis);and finally, the adoption stage in which he finally adopts the innovation completely on him own farm.

Regarding the diffusion of innovation several hypotheses have been formulated to explain it. Such as farmers are not properly motivated, lack of knowledge, failure of extention agencies to bring about the change, whether uncertainties, social structure of the farmers and so on.

Many events clearly reveal that innovation is not accepted promptly in any region but it takes time for the acceptance to all or the majority of the people. In the beginning there is tough resistance but gradually it becomes weaken with the constant efforts of the extension workers as they conceive the adopter with the utility and profits of that innovation. However, in the present study attempt has been made to find out whether the adoption of innovations follow any definite pattern and, if so, what is the nature of the pattern. The answer to this question is significant in three respects. Firstly, it has direct relevance to socio-economic change and the perception studies about the adoption of an innovation; secondly, it is very important to the agricultural extension worker who would like to know the way of farmers who are likely to behave when he introduces an agricultural innovations. The hypothesis predicting the movement of diffusion curve will enable him to frame his extension teaching programme more effectively, thirdly, the anthropologist who deals with the problem of diffusion of cultural traits would be interested to know in what ways such cultural traits diffuse in a community and, is there any relationship in the diffusion of cultural traits and that agricultural innovations.

In order to study the trend and pattern of diffusion of agricultural innovations, the Upper Ganga-Yamuna Doab has been selected as a study area. The selection of the area for the present analysis is due to certain advantages. Firstly, district-wise data of fertilizer consumption kg/ hectare, are available. The area is under intensive irrigation. Besides this it experienced Green Revolution comparatively earlier than other parts of the region of Uttar Pradesh. The adequate irrigation facilities helped in bringing the use of high consumption of fertilizer and high yielding varieties of seeds and finally, the literacy index is comparatively better than that of the other areas of Ganga-Yamuna Doab.

The district has been taken as a unit of study at present. There are five districts in Upper Ganga-Yamuna Doab namely, Saharanpur, Muzaffarnagar, Meerut, Bulandshahr and Ghaziabad. The data of the consumption of fertilizer, irrigation, pesticides, implements and high yielding varieties have been collected from the secondary sources of data i.e., Agricultural Statistics Bulletin of Uttar Pradesh for all the agricultural year from 1970 to 1993 of all the districts of Upper Ganga-Yamuna Doab except Ghaziabad for which the data has been collected from 1976 to 1993 because Ghaziabad came into existence in 1976.

Many scholars have used various statistical techniques for the analysis of the trend of diffusion of innovations in different parts of the world. Some specific work has been done by Bryce Ryan[1], (1948) Bryce Ryan and Gross[2] (1943) and Zvi Griliches[3] (1957). All of them have studied the diffusion of innovation of hybrid seeds of corn in various states of U.S.A. which is initially different in socio-economic set up to the study area, and have found that the trend is non-linear. However, in the present study the trend of diffusion is non-linear for each of the districts and all curve are either convex or concave having an upward trend. It is therefore, in the present study non-linear regression has been used to form exponential such as second degree and logistic curve.

The straight line indicates a constant amount of increase or decrease a second degree curve involves increasing and decreasing amount of adoption of innovations. However, almost all the districts meet this condition of second degree curve by having increasing amount of use of fertilizers. The second degree curve involves merely and addition of cx^2 to the equation of a straight line given as follows:

$$Yc = a + bx + cx^2.$$

Where a, b and c are constant and x is time variable. Second degree curve is fitted to the data of consumption of fertilizer from 1970-71 to 1993-94 taking 1981-82 as given in the result, that the years 1981-82 and 1982-83 have X values as -1 and $+1$ respectively. The calculated trend values have been given in the corresponding tables of each district. The logistic curve is Pearl-Reed curve, which is merely a modified exponential curve can be written as:

$$Yc = \frac{K}{1+10^{a+bx}}$$

Where K, a and b are constant and x is time variable. In order to fit this equation three points of time of equidistant from one another. The three selected values through which the curve possess are fertilizer consumption values associated with these points of time. These values are designated as a, b and c. With the help of these values the three constants K, a and b are obtained from least square method. This logistic curve in its K values with negative b values always gives an upper asymptote value. Since the K values varies with different values of a, b and c, it is highly subjective.

The efficacy of these two estimates are tested by determining the coefficient of correlation between the observed and calculated values. However, it would be worthwhile to give the result of these findings district-wise together. With the geographical setting of each district so that the correlation, if any, may also be given side by side.

TREND OF DIFFUSION OF CONSUMPTION OF FERTILIZERS

Fertilizer has played the role of kingpin because when soil fertility is low, better germ plasm fail to show postulated yield differentials. The continuous deteriorating soil fertility on account of regular cultivation can also be replenished to a great extent by resupplying nitrogen in the soil through the use of fertilizers, and plant yields can be stepped up by the use of adequate nutrition in the form of fertilizers. Fertilizers can thus play a significant role in providing a major break through in agricultural production.

The trend of diffusion of consumption of fertilizers has been examined district wise and region as a whole through actual values of irrigation and trend values of second degree and logistic curve. However, the geographical setting of each district has not been described because it has already been discussed in earlier chapter.

Saharanpur

The district of Saharanpur lies in the north western part of Upper Ganga-Yamuna Doab its covers an area of 44736 thousand hectares, out of which net sown area is 274527 hectare and the area sown more than once is 172779 hectares. The total irrigated area is 74.23 percent and total population 2309 thousand giving a density of 626 person per square km. The literacy rate of the district is 42.11 percent. The district has almost uniform topography, the district comes under dry-humid climate, the annual rainfall is 60 cm. The irrigation facility is adequate and considerable portion of the net sown area is irrigated through canal and tube well.

Table 4.1 shows the trend of consumption of fertilizers together with computed trend values of second degree curve and logistic curve. In the base year the consumption was 28.89 kg per hectare (1970-71) which was increased 137.70 kg. per hectare. In 1993-94 i.e., the consumption has increased 4.77 times of the base

Trend of Diffusion of Consumption of Fertilizer

Year	Table 4.1 Saharanpur			Table 4.2 Muzaffarnagar			Table 4.3 Meerut			Table 4.4 Bulandshahr			Table 4.5 Ghaziabad			Table 4.6 Upper Ganga-Yamuna Doab		
	Actual Consumption Kg/hect.	Trend Values		Actual Consumption Kg/hect.	Trend Values		Actual Consumption Kg/hect.	Trend Values		Actual Consumption Kg/hect.	Trend Values		Actual Consumption Kg/hect.	Trend Values		Actual Consumption Kg/hect.	Trend Values	
		Second Degree Curve	Logistic Curve		Second Degree Curve	Logistic Curve		Second Degree Curve	Logistic Curve		Second Degree Curve	Logistic Curve		Second Degree Curve	Logistic Curve		Second Degree Curve	Logistic Curve
1970-71	28.89	26.83	3.29	38.99	42.86	1.45	39.03	32.68	17.07	26.44	17.12	8.28	–	–	–	–	–	–
1971-72	37.84	31.34	4.34	47.95	45.48	2.03	44.86	39.84	20.31	27.73	23.14	11.24	–	–	–	–	–	–
1972-73	41.10	36.21	5.72	56.95	48.26	2.85	52.71	46.69	24.07	31.30	28.90	13.98	–	–	–	–	–	–
1973-74	28.90	41.04	7.50	53.08	51.21	3.98	40.45	53.24	28.40	23.00	34.39	16.13	–	–	–	–	–	–
1974-75	36.43	45.81	9.82	44.13	54.32	5.55	39.27	59.49	33.34	30.93	39.63	18.56	–	–	–	–	–	–
1975-76	54.07	50.54	12.80	46.13	57.60	7.71	50.41	65.44	38.90	35.97	44.60	21.59	–	–	–	–	–	–
1976-77	54.10	55.21	16.60	66.76	61.04	10.67	70.41	71.09	45.10	49.02	49.30	26.30	43.78	59.48	33.89	56.40	62.20	5.46
1977-78	64.55	59.84	21.39	61.49	64.65	14.69	92.30	79.43	51.92	45.75	53.75	29.75	78.22	66.32	36.66	68.00	66.85	8.15
1978-79	59.42	64.43	27.33	71.12	68.44	20.08	87.98	81.48	59.29	69.83	53.94	35.93	67.69	/2.95	44.02	70.60	71.38	12.04
1979-80	69.00	68.96	34.58	66.28	72.38	27.18	87.23	86.22	67.14	45.01	61.86	41.86	73.36	79.38	50.01	68.00	75.80	17.50
1980-81	75.00	73.45	43.22	75.44	76.50	36.31	100.57	90.66	75.35	80.03	65.53	46.35	86.12	85.59	56.67	83.20	80.09	24.87
1981-82	78.21	77.88	53.25	106.81	80.78	47.73	106.81	94.80	83.79	81.78	68.93	55.35	100.98	91.60	64.04	94.20	84.27	34.33
1982-83	83.82	86.91	64.55	91.37	89.84	61.49	104.18	102.18	92.30	77.33	74.94	65.78	106.95	97.39	72.15	92.20	88.33	45.70
1983-84	89.91	90.90	76.85	95.69	94.62	77.38	110.84	105.41	100.72	88.11	77.55	75.13	111.34	102.98	81.01	98.60	92.27	58.33
1984-85	109.53	95.15	89.73	97.67	99.56	94.82	106.52	108.35	108.90	76.84	79.91	80.25	113.40	108.36	90.62	100.20	96.09	71.20
1985-86	102.78	99.35	102.73	113.01	104.67	109.93	116.74	110.98	116.71	94.95	81.99	83.31	115.81	118.50	100.98	108.00	103.38	83.20
1986-87	91.42	103.50	115.31	104.23	109.95	130.72	105.43	113.31	124.03	78.04	83.83	85.34	139.76	123.25	112.05	103.40	106.85	93.51
1987-88	118.08	103.60	127.05	99.19	115.40	147.22	96.02	115.34	130.78	62.21	85.40	88.45	136.11	124.80	123.76	102.20	110.20	101.75
1988-89	91.68	111.65	137.62	118.06	121.01	161.76	109.19	117.07	136.91	89.81	86.70	90.71	108.12	132.13	136.06	103.00	113.43	107.98
1989-90	132.75	115.66	146.82	122.78	126.79	173.99	116.83	118.50	142.41	79.53	87.74	93.31	111.74	136.26	148.83	112.00	116.54	112.48
1990-91	127.85	119.61	154.62	132.75	132.74	183.89	119.06	119.63	147.28	90.00	88.52	98.01	121.80	140.18	161.97	117.80	119.54	115.63
1991-92	109.08	123.53	161.07	134.60	138.65	191.65	124.13	120.45	151.55	93.00	89.04	101.00	139.27	143.89	175.35	119.80	122.42	117.79
1992-93	121.18	127.39	166.30	147.28	145.13	197.59	113.53	120.97	155.25	93.88	89.29	104.00	154.21	147.39	188.82	125.60	125.17	119.24
1993-94	137.70	131.20	170.48	161.87	151.57	202.04	136.96	121.19	155.85	88.71	89.34	110.00	175.46	150.68	202.25	139.40	127.81	122.06

year. Although there is overall increase in the consumption of fertilizers, but it has increased tremendously after 1980-81.

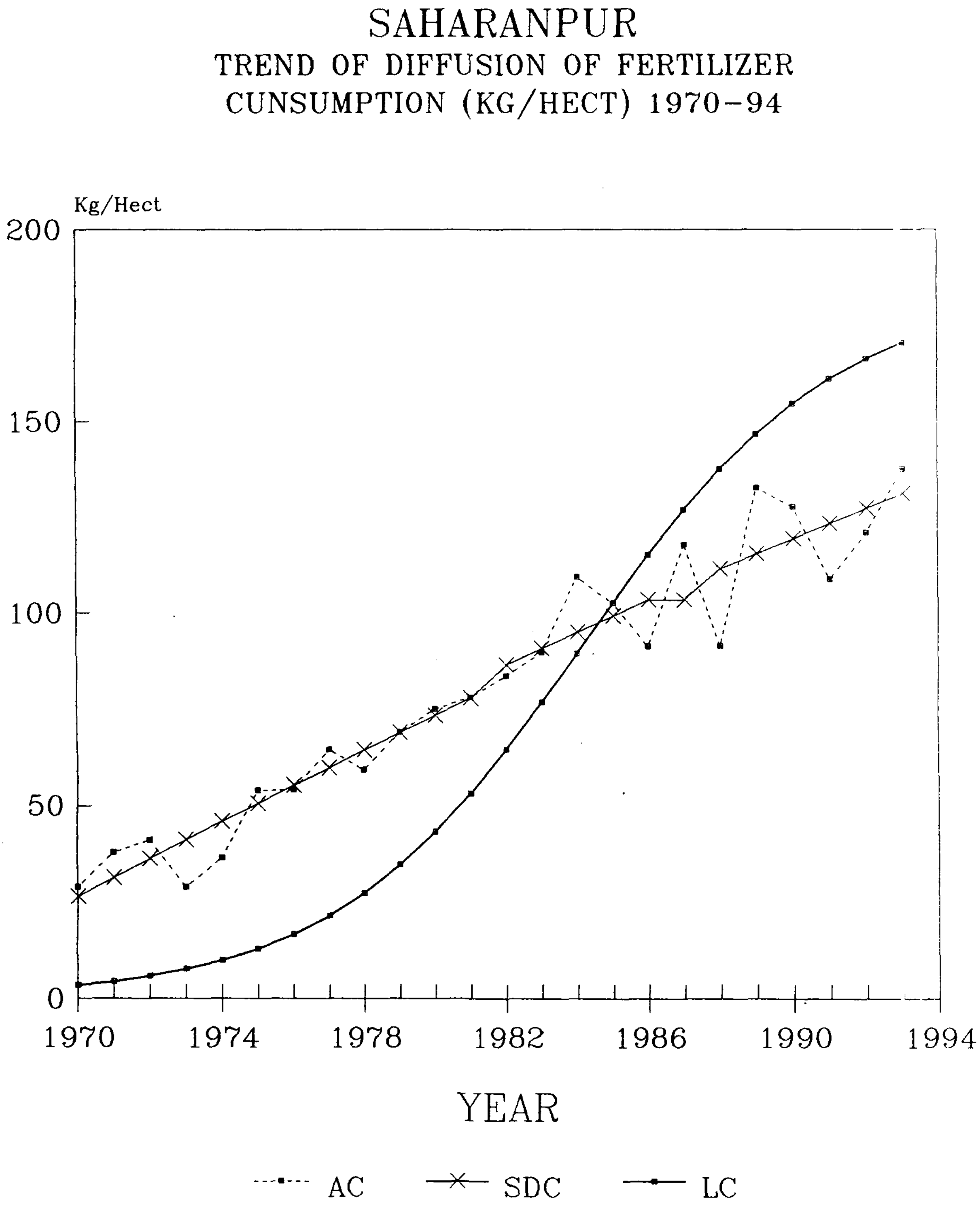
Figure 4.1 reveals the trend line of actual consumption of fertilizers runs close to second degree curve upto 1983-84 and there after the second degree curve runs in fluctuating manner though their closeness is not as much as before 1993-94.

However, a close view of the trend line reveals that the actual curve is closer to the line as compare to the line of logistic curve upto 1993-94 but the trend line of logistic curve shows the upward trend and becoming closer to the line of actual curve. It crossed at the point of 1985-86 and then moves upward in curving linear forms. The whole view represents S shape. It proved that the patterns of diffusion of fertilizer follow the logistic curve.

Muzaffarnagar

The district of Muzaffarnagar is located in the northwestern part of Upper Ganga-Yamuna Doab. It covers an area of 509279 thousand hectare, out of which the net sown area and area sown more than once are 323847, 185 432 hectare respectively. It lies in the homogenous plain with loamy soil of high fertility. It experiences annual rainfall about 63 cm. The total population of the district i.e., 2843 thousand giving a density of 709 person per square k.m. The total irrigated area is 96.06 per cent, being dry humid climatic zone, it has adequate facility of irrigation and therefore, the considerable portion of the net sown area is irrigated with canals and tube wells.

Table 4.2 shows the actual consumption of fertilizer, second degree curve and logistic curve. In the base year the consumption of fertilizer was 38.99 kg. per hectare (1970-71) to 161.87 kg. per hectare (1993-94) i.e., about 4.15 times of the base year. Although there is over all increase in the consumption of fertilizer during the



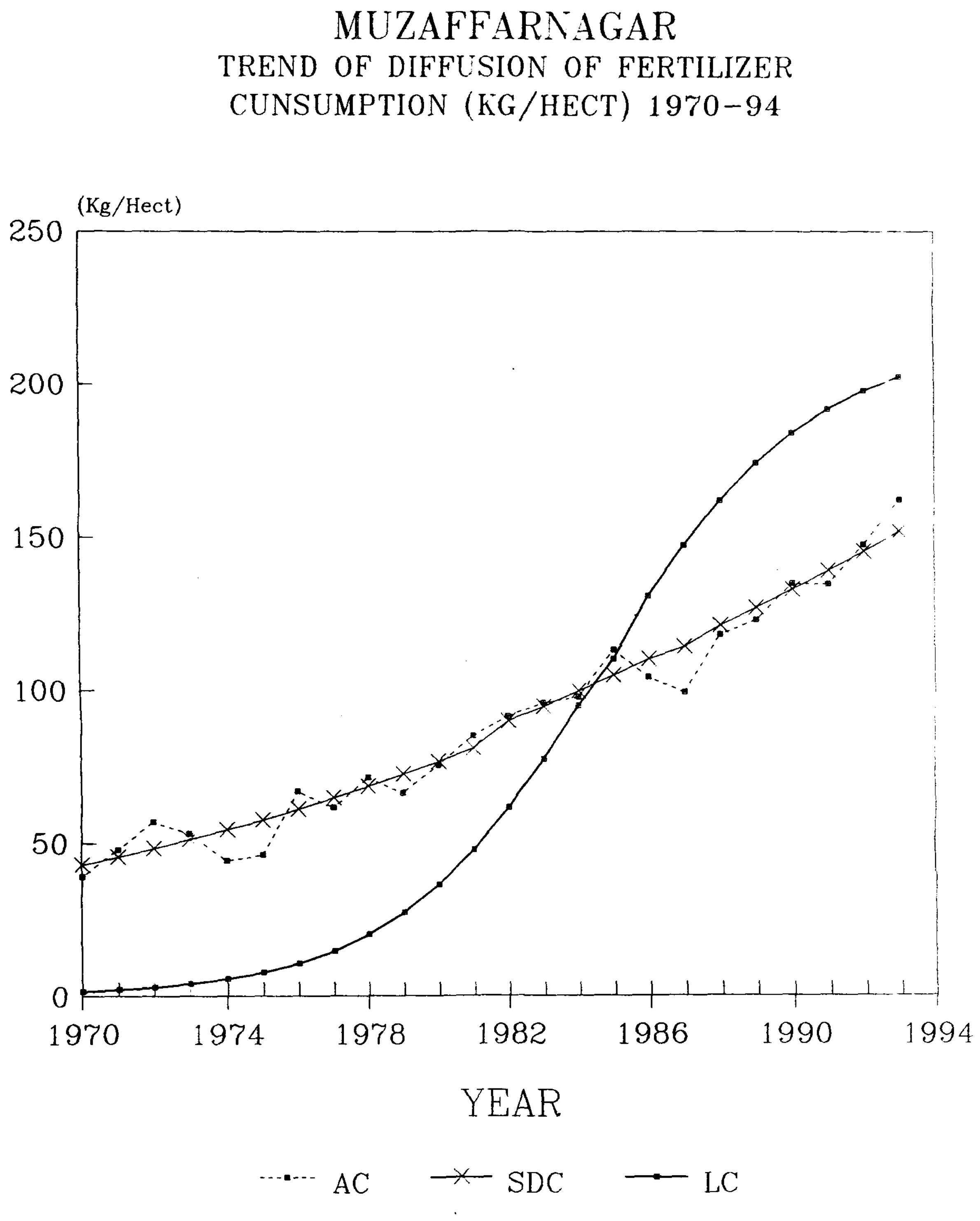
AC : ACTUAL CURVE
SDC: SECOND DEGREE CURVE
LC : LOGESTIC CURVE

Fig. 4.1

period of study. But there is considerable fluctuation in its trend from 1981-82 to 1988-89. However, the consumption has increased and has reached to 161.87 in 1993-94 that is almost double from 1987-88 upto 1993-94. Figure 4.2 shows the curves plotted with the help of actual consumption and computed values of second degree and logistic curve. The trend lines of actual consumption and second degree curve run very close to each other from beginning to an end except 1974-75 and 1986-87 where the lines are relatively set a part. However, actual curves moves much closer to the curve of the second degree curve as compared to the logistic curve which clearly indicates that diffusion of fertilizer in these district has followed the trend of second degree curve. The result of the coefficient of correlation also proved the same facts.

Meerut

The district of Meerut with an area of about 504393 thousand hectares is the third largest district of the Upper Ganga-Yamuna Doab. It lies in a homogenous plain having loam and silty loam soil. The average annual rainfall varies from 50 to 60 cm. The district fells into dry sub humid types of climate. Agriculture is the main occupation of the people. The net sown area and area sown more than once are 311732, 192661 hectares respectively. The district is well served with efficient means of irrigation, canal and tube, well are the main sources of irrigation, which accounts 92.66 per cent of the total cultivated area. The district accounts 3448 thousand total population having density of 882 person per square km. Table 4.3 giving actual consumption of fertilizer and trend values of second degree and logistic curves reveals interesting trend. There is a considerable increase in its consumption from 1987-88 to 1993-94. Although there is over all increase in the consumption of fertilizers but there is considerable fluctuation in its trends during 1973-74 to 1975-76 and 1986-87 to 1987-88. However, this fluctuation is



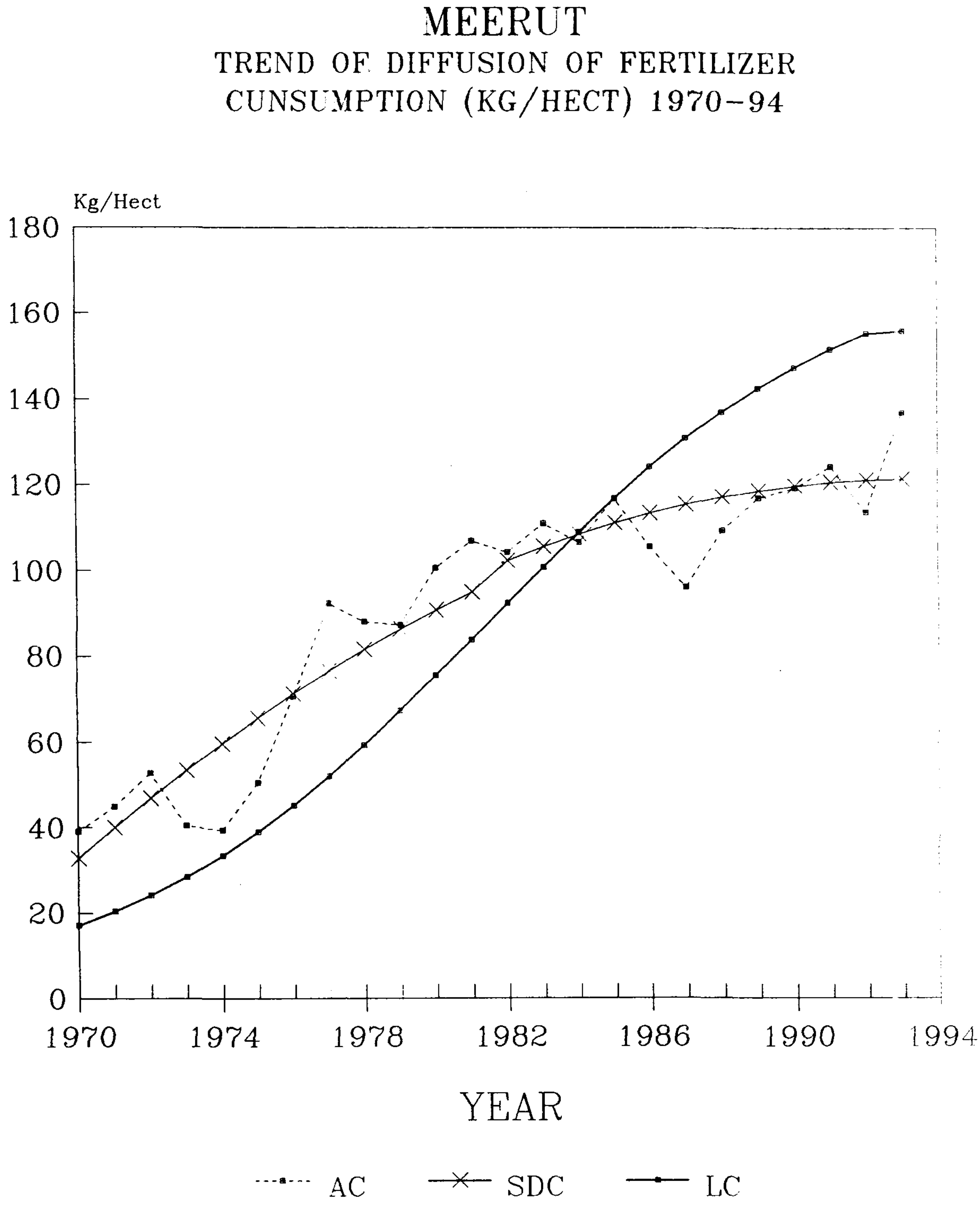
AC : ACTUAL CURVE
SDC: SECOND DEGREE CURVE
LC : LOGISTIC CURVE

Fig. 4.2

insignificant. The actual consumption and the trend values of second degree and logistic curves are plotted. Figure 4.3 shows the actual curve, running almost closely with the other two curve upto 1984-85 but there after logistic curves follows a separate path. However, a close views of these curve indicate that actual curve runs relatively closer to the curve of second degree. Which is also proved by the result of the coefficient of correlation. The coefficient of correlation of second degree curve is 0.6542 and 0.4169 in case of logistic curve. Hence, it is clear that the trend of the diffusion of fertilizer in Meerut district fallows second degree curve.

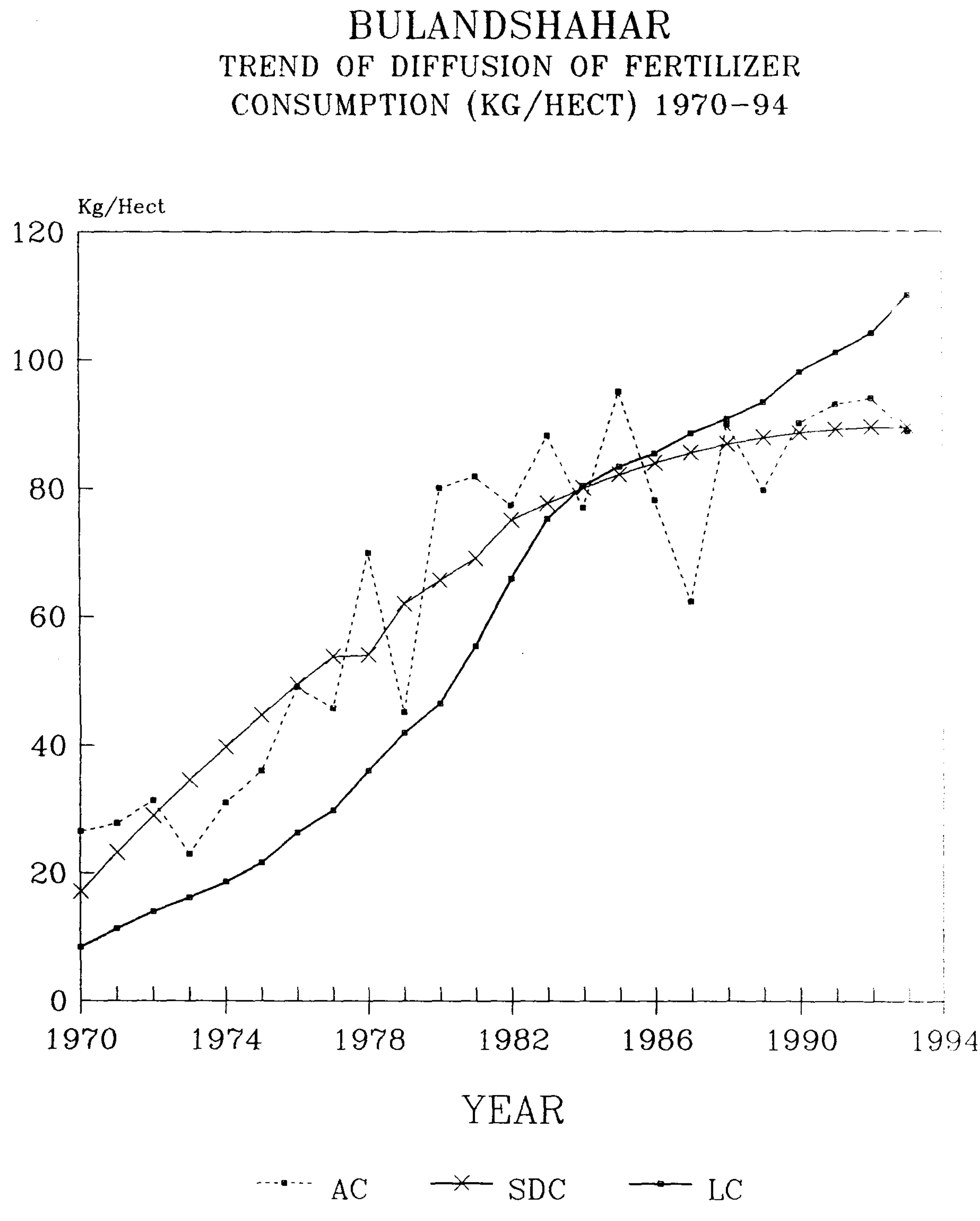
Bulandshahr

Bulandshahr lies in the southern part of Upper Ganga-Yamuna Doab and covers an area of 587125 thousand hectare, which is the largest district of the study area. It has 2850 thousand population with a density and literacy of 655 person per square kilometer and 44.71 percent respectively. Bulandshahr district is characterised by almost uniform topography with the penetration of flood prone area of Ganga-khadar. But a considerable portion of the district cultivated and more than 70 percent population is engaged in agriculture. Like other district the amount of rainfall in low, ranging between 60 to 65 cm. per annum. The district comes under dry land area, the irrigation facility in the district are adequate, which accounts more than 85 percent area is under irrigation. Table 4.4 shows the actual consumption of fertilizer along with the trend values of second degree curve and logistic curve. There is general tendency of increase in the consumption of fertilizers but there are several fluctuations in the consumption of fertilizers, with the exception of the year 1987-88 where there is a steep fall in its consumption. Figure 4.4 shows the curve for actual consumption and trend values of second degree and logistic curves. Both the



AC : ACTUAL CURVE
SDC: SECOND DEGREE CURVE
LC : LOGISTIC CURVE

Fig. 4.3



AC : ACTUAL CURVE
SDC: SECOND DEGREE CURVE
LC : LOGISTIC CURVE

Fig. 4.4

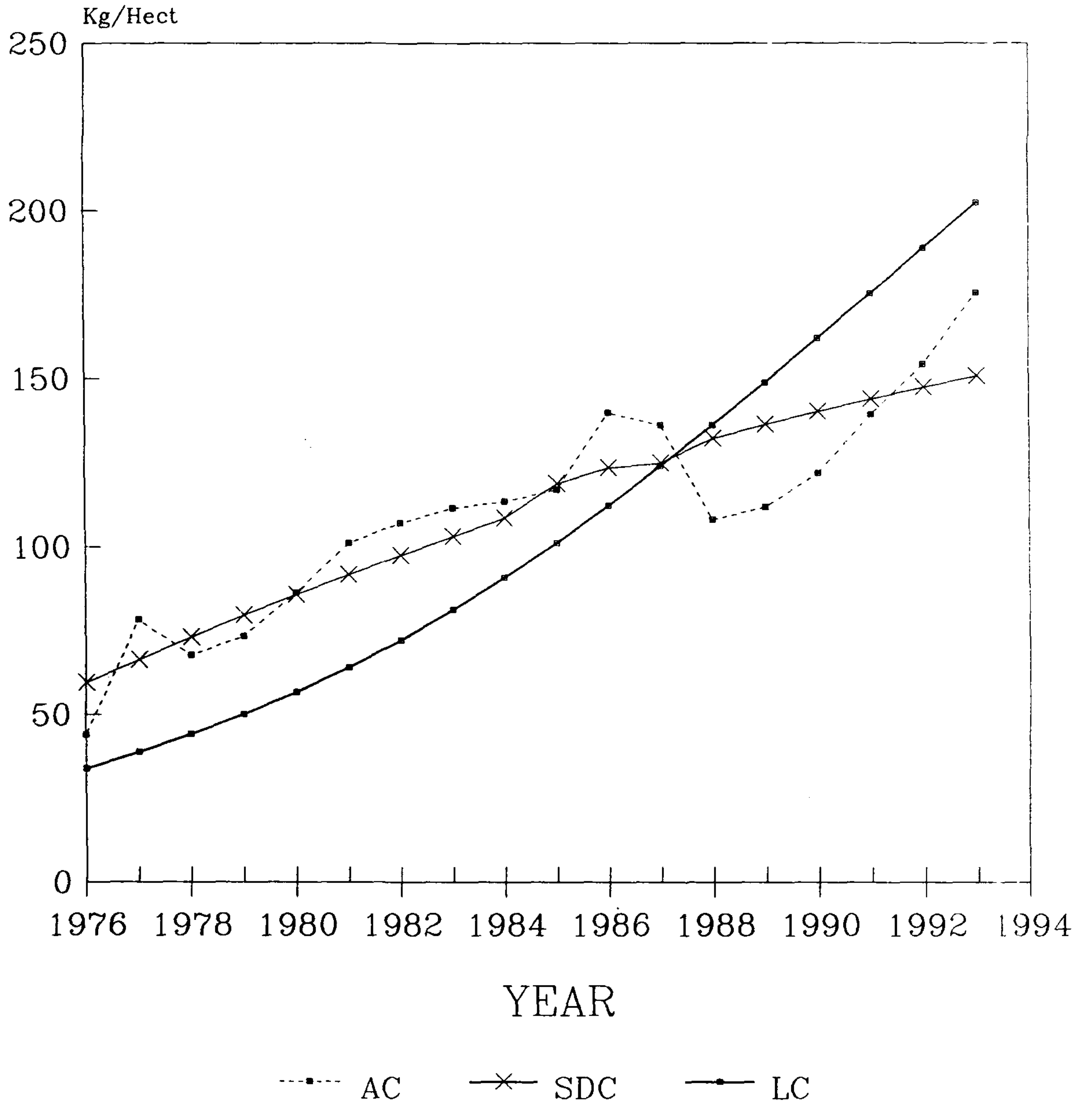
curves of the trend values run almost along the curve of actual consumption. The second degree curve has greater fluctuation throughout the year while the logistic curve follows the uniform trend and becoming more closer to actual trend, which indicates that the process of diffusion of innovation followed both the curves. The coefficient of correlation further strengthens this fact through its value i.e., 0.7586 in case of second degree curve and 0.3635 in case of logistic curve.

Ghaziabad

Ghaziabad is the smallest district of Upper Ganga-Yamuna Doab with an area of 300363 thousand hectare. It lies in homogenous plain consisting of fertile loamy soil. More than two third of the total area is cultivated, and majority of the population is engaged in agriculture. The average annual rainfall is 65 cm. It supports the population of 2,704,000 giving density of 1044 person per square kilometer and literacy rate is 56.22 percent. The main sources of irrigation are canals and tube wells, which accounts 95.40 percent irrigation in the district.

Table 4.5 indicates the actual consumption of fertilizer kg per hectare and the values of second degree and logistic curve. The consumption of fertilizer in 1976-77 was very low perhaps, because of the low adoption innovation diffusion but it has picked up after 5 years and become more than doubled. The consumption has increased almost more than four times from the base year that is 1976-77 to 1993-94. The actual values, trend values of second degree and logistic curve are plotted in Figure 4.5, which reveals interesting result up to 1987. All the three lines run close to one to another. After 1987 the logistic curve have gone further up, where as the line of actual consumption goes below and there after it starts rising and follows the trend of logistic curves. However, all the three lines run close to one another. Second degree curve and

GHAZIABAD
TREND OF DIFFUSION OF FERTILIZER CONSUMPTION (KG/HECT) 1976-94



AC : ACTUAL CURVE
SDC : SECOND DEGREE CURVE
LC : LOGISTIC CURVE

Fig. 4.5

logistic curves indicate that line of second degree curve in comparison to the line of logistic curve is much closer to the actual values leaving exception apart. Hence it may be concluded that diffusion of fertilizer in these district has followed second degree curve.

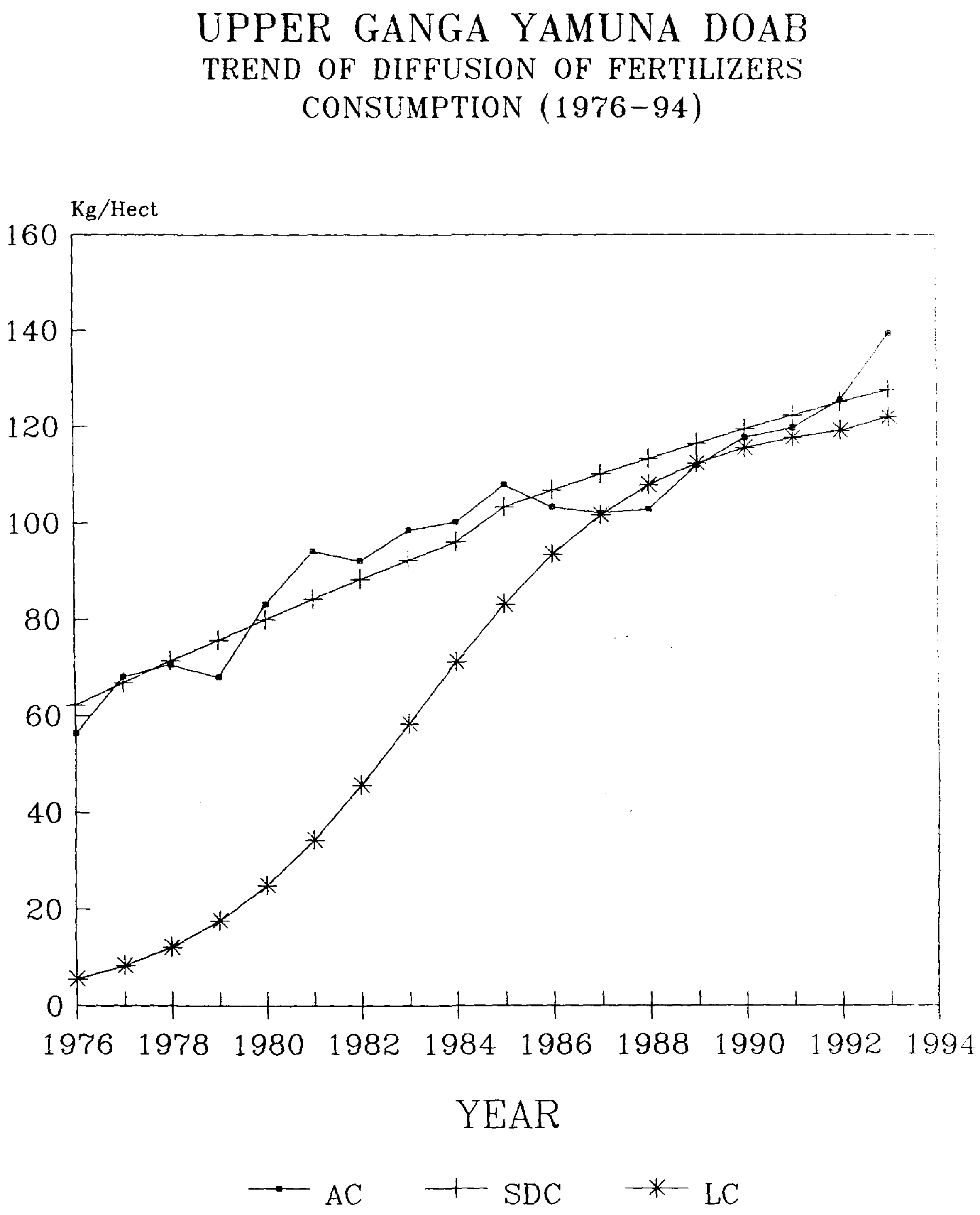
Upper Ganga-Yamuna Doab

At the end it would be worthwhile to examine the trend of diffusion of fertilizer in Upper Ganga-Yamuna Doab as a whole to test wheather it is in accordance with the trends of the individual districts are not.

Table 4.6 shows that there is over all increase in its consumption. It has increased from 56.40 kg per hectare in 1976-77 to 139.40 kg. per hectare in 1993-94 which is more than 2.47 times of the base year. However, upto 1982-83 the growth was gradual and there after the consumption has sharply increased. This is a general trend found in all the districts, it is either due to non-availability of the fertilizer or low adoption of innovation.

Figure 4.6 showing the trend line of the actual consumption and computed values of second degree and logistic curve reveal the two trend line of actual and second degree curve run very close to each other. Where as the logistic curve is set a part but showing upward trend. Therefore, it may be concluded that diffusion of fertilizer in Upper Ganga-Yamuna Doab as a whole followed second degree curve, which is in accordance with the finding of the individual districts of the study area.

After foregoing discussion it may be concluded that the present study examined briefly the problem of technological change and spatial diffusion of agriculture innovation in Upper Ganga-Yamuna Doab. It is quite obvious from the study that the process of diffusion of agricultural innovations is slow in the study area But with the passage of time it is broken down and the rate of adoption



AC : ACUTAL CURVE
SDC: SECOND DEGREE CURVE
LC : LOGISTIC CURVE

Fig. 4.6

increases slowly. In the latter half of the adoption process is very rapid. The diffusion process more or less follow the trend of second degree curve and it took a considerable time. And if the basic problem in planning is to narrow down the line lag between the introduction of an innovations and their wide spread of diffusion in the study area, we need to study more about various aspects of technological change and its spatial diffusion.

TREND OF DIFFUSION OF IRRIGATION

Irrigation is indeed the life-breath of agriculture. Its importance lies in the development of agriculture in general and monsoonal countries in particular hardly need any emphasis. Very often it plays a decisive role in selection of crop to be sown, cropping pattern, intensity of cropping, crop combination extent of yield and time of sowing the crop. A number of analytical studies have proved that. India can increased its agricultural production to a large extent, if adequate an assured irrigation are made available. In addition to this, assured irrigation effects to great extent the adoptions of certain agricultural innovations, like chemical fertilizer and manure, new variety of seeds, plant protection chemical, because these innovations required assured and high doses of irrigation water. Many studies conducted which reveals the impact of irrigation facilities on adoption of agricultural innovations has a positive correlation between the two variables wise. Farmers with adequate and assured irrigation facilities adopt improved agricultural practices much earlier as compare to others. However, in the present study an attempt has been made to exhibit the trend of diffusion of irrigation through some statistical techniques based on non-linear regression analysis. Of the non-linear to forms of exponential are second degree curve and logistic curve. The methodology used to examine the trend of diffusion of irrigation are the same with that of trend of diffusion of fertilizer consumption in the preceding part of the chapter.

The study area has a vast reservoir of surface and ground water, fertile soils and better climatic conditions. This region is drained by the perennial river of the Ganga system, which has their source in the Himalayas. The vast level plain and gentle slope provides every facility for the construction and development of the canal. Percolation from the rivers and canal contributes to maintained the sub-soil water table. The study area i.e., Upper Ganga-Yamuna Doab received 60 to 70 cm. rainfall, and 90 percent of total rainfall occurs during the rainy season. During the rainy season there are long dry spells in between irrigation. Therefore, it is necessary for the growing of crops and it is desirable even in the rainy season to counter the effects of short dry spells .The study reveals that there was a massive expansion of irrigation between 1970-71 to 1993-94. The net irrigated area is 97 percent in 1992-93, where tube well alone accounts 43.6 percent against 17.87 percent in 1970-71. It shows the rapid increase of irrigated area under tube well. Similar trend is also found in canal irrigation, which accounts 35.34 percent to 42 percent in 1970-71 and 1993-94 respectively.

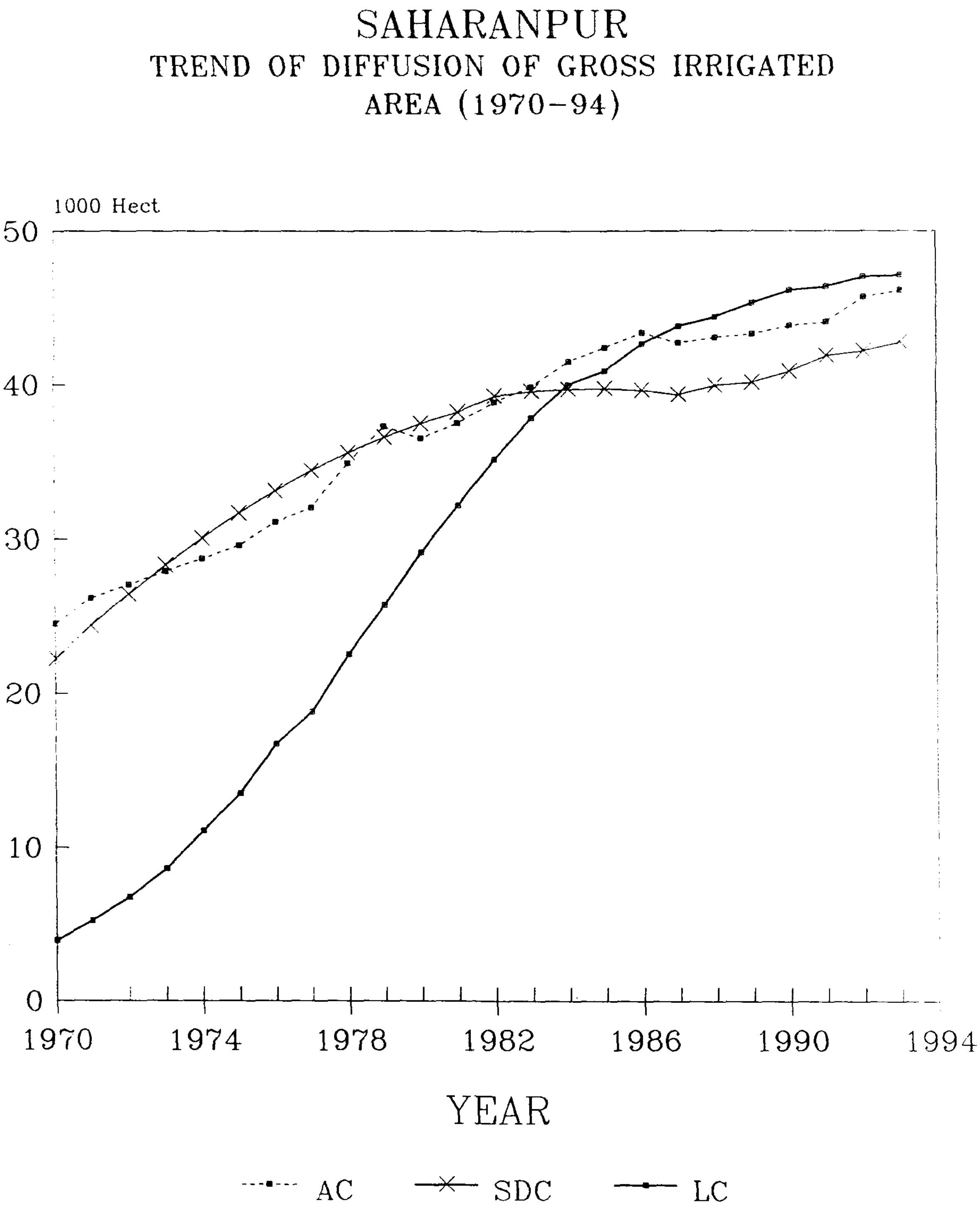
The trend of diffusion of irrigation has been examined district wise and region as a whole through actual values of irrigation and trend values of second degree and logistic curve. However, the geographical setting of each district has not been described because it has already been discussed in the analysis of trend of diffusion of fertilizer consumption district wise in the preceding part of the chapter.

Saharanpur

Table 4.7 shows the trends of gross irrigated area with the trend values of second degree and logistic curves. There is over all increase in the gross irrigated area from the base year 1970-71 to 1993-94. But there are some fluctuations, which may be attributed to the change in the cropping pattern. In Figure 4.7 the trend lines for gross irrigated area, and computed values of second degree curves are plotted. A close view of the trend lines reveals that the actual curve runs very close to the second degree curve where as the logistic curve is set a part from both the curve but it has upward trend and crosses the second degree curve. And becomes *closer to*

Trend of Diffusion of Irrigation

Year	Table 4.7 Saharanpur			Table 4.8 Muzaffarnagar			Table 4.9 Meerut			Table 4.10 Bulandshahr			Table 4.11 Ghaziabad			Table 4.12 Upper Ganga - Yamuna Doab		
	Gross Irrigated Area 10,000 hect.	Trend Values		Gross Irrigated Area 10,000 hect.	Trend Values		Gross Irrigated Area 10,000 hect.	Trend Values		Gross Irrigated Area 10,000 hect.	Trend Values		Gross Irrigated Area 10,000 hect.	Trend Values		Gross Irrigated Area 10,000 hect.	Trend Values	
		Second Degree Curve	Logistic Curve		Second Degree Curve	Logistic Curve		Second Degree Curve	Logistic Curve		Second Degree Curve	Logistic Curve		Second Degree Curve	Logistic Curve		Second Degree Curve	Logistic Curve
1970-71	24.49	22.22	3.92	34.20	33.43	4.90	36.32	35.29	0.10	38.07	37.02	0.42	–	–	–	–	–	–
1971-72	26.18	24.39	5.22	34.71	34.17	6.23	38.24	36.11	0.18	40.54	38.16	0.67	–	–	–	–	–	–
1972-73	27.06	26.42	6.74	35.16	34.90	7.85	38.52	36.89	0.34	39.78	39.27	1.07	–	–	–	–	–	–
1973-74	27.94	28.30	8.58	35.61	35.62	9.79	38.92	37.01	0.62	39.01	40.37	1.67	–	–	–	–	–	–
1974-75	28.74	30.04	11.08	36.37	36.32	12.09	40.58	37.42	1.14	44.78	41.45	2.61	–	–	–	–	–	–
1975-76	29.46	31.64	13.51	34.86	37.00	14.73	39.20	39.91	2.06	41.52	42.52	4.04	–	–	–	–	–	–
1976-77	31.07	33.10	16.69	36.79	37.68	17.69	39.56	40.01	3.67	40.72	43.57	6.16	23.51	22.91	1.04	171.23	168.87	79.71
1977-78	31.99	34.41	18.81	37.15	38.33	20.91	38.20	42.73	6.39	38.98	44.60	9.21	22.97	23.68	1.84	169.33	176.07	89.98
1978-79	34.92	35.58	22.51	39.53	38.98	24.29	40.01	43.11	10.65	39.86	45.61	13.42	23.03	24.39	3.18	177.63	182.72	100.75
1979-80	37.29	36.60	25.71	40.58	39.61	27.71	45.32	45.83	16.69	48.82	46.61	18.43	26.01	25.05	5.33	196.66	188.82	112.01
1980-81	36.53	37.48	29.71	41.56	40.22	31.07	44.45	46.66	24.08	46.91	47.59	25.27	25.92	25.66	8.45	194.89	194.38	123.45
1981-82	37.50	38.22	32.12	40.30	40.83	34.25	45.28	46.99	31.70	50.23	48.55	32.22	26.30	26.22	12.46	198.92	199.40	134.93
1982-83	38.87	39.26	35.15	41.44	41.99	37.15	50.24	47.83	38.25	59.30	50.43	38.98	27.13	26.73	16.86	212.04	203.86	146.25
1983-84	39.84	39.57	37.86	41.16	42.55	39.72	45.51	47.80	43.07	49.40	51.34	44.92	27.24	27.18	20.91	202.80	207.79	157.24
1984-85	41.50	39.73	38.99	44.65	43.10	41.95	47.70	48.33	46.23	50.75	52.24	49.71	27.82	27.59	24.10	212.14	211.16	167.75
1985-86	42.43	39.75	40.90	43.84	43.63	43.84	48.57	49.44	48.14	53.30	53.12	53.28	28.35	28.23	26.30	216.06	216.28	177.63
1986-87	43.41	39.63	42.65	44.83	44.15	45.39	49.62	49.69	49.24	54.42	53.98	55.82	28.36	28.48	27.68	219.41	218.02	186.8
1987-88	42.75	39.36	43.83	45.34	44.65	46.66	50.75	50.55	49.86	58.01	54.83	57.54	28.99	28.67	28.51	222.67	219.21	195.19
1988-89	43.10	39.95	44.53	46.17	45.14	47.68	50.90	50.89	50.20	54.42	55.66	58.69	28.38	28.81	28.96	220.88	219.86	202.77
1989-90	43.32	40.17	45.35	45.61	45.62	48.50	51.16	51.33	50.39	56.72	56.47	59.43	28.41	28.90	29.25	213.16	219.97	209.56
1990-91	43.86	40.87	46.15	45.02	46.08	49.14	51.46	51.00	50.49	57.90	57.27	59.91	28.65	28.94	29.40	213.51	219.52	215.57
1991-92	44.09	41.9	46.37	45.47	46.53	49.64	51.58	52.22	50.55	57.69	58.04	60.22	28.47	28.92	29.48	214.29	216.54	220.66
1992-93	45.73	42.21	47.00	46.85	46.96	50.03	52.02	53.11	50.58	57.20	58.80	60.42	28.93	28.85	29.53	218.54	217.00	225.43
1993-94	46.15	42.76	47.12	47.69	47.38	50.33	53.48	53.75	50.60	58.69	59.55	60.54	29.48	28.74	29.55	222.22	214.93	247.68



AC : ACTUAL CURVE
SDC : SECOND DEGREE CURVE
LC : LOGISTIC CURVE

Fig. 4.7

the actual as well as second degree curve after 1983–84 and onwards. It proves that the trend of diffusion of gross irrigated area follows the patterns of the line of coefficient of correlation. The values of second degree and logistic curves are 0.5629 and 0.2986 respectively. Therefore, it is clear that trend of diffusion of gross irrigated area follows second degree curves.

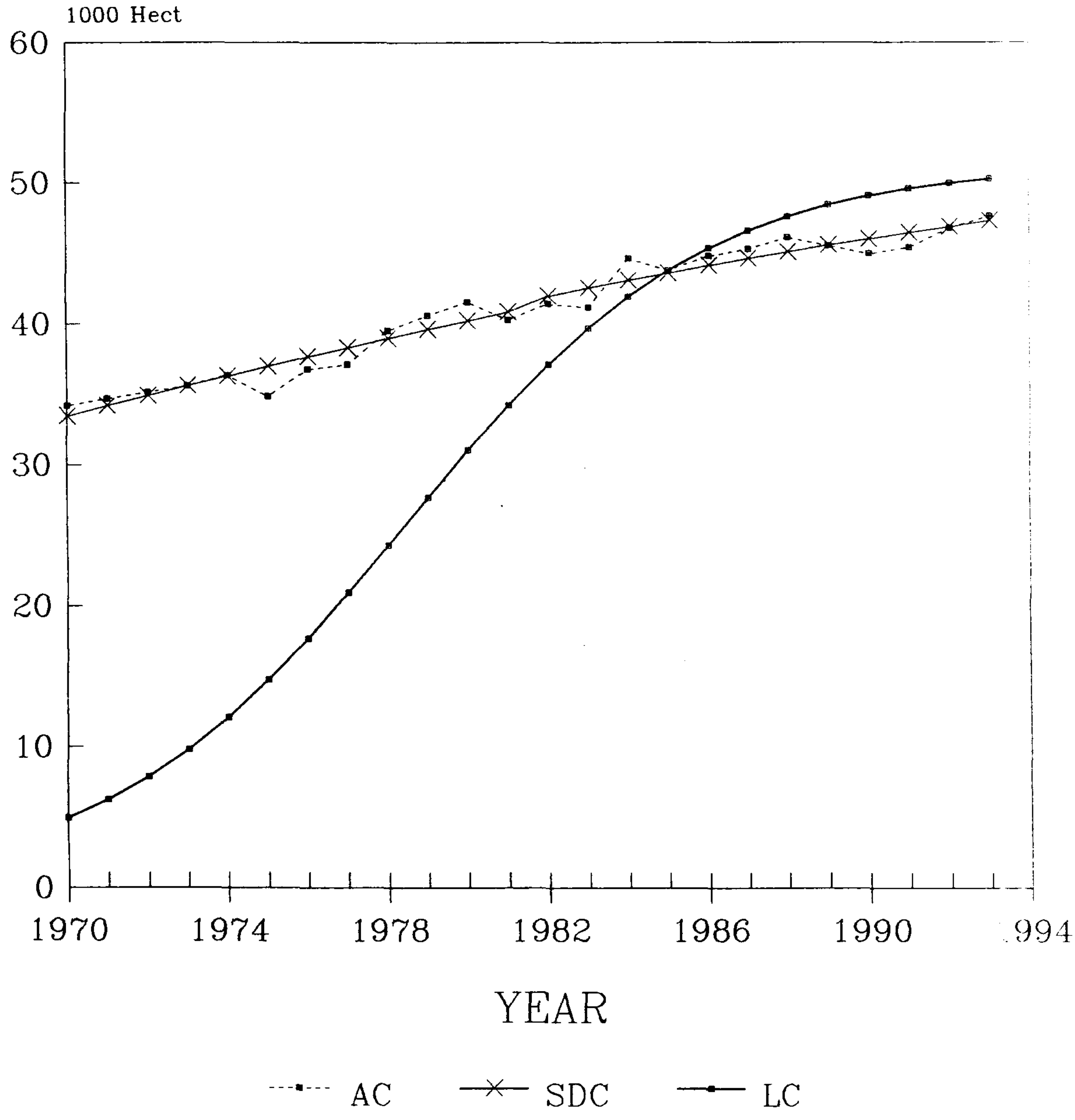
Muzaffarnagar

Table 4.8 shows the actual value of gross irrigated area along with the trend values of the second degree curve and logistic curve. There is general tendency of increase in the gross irrigated area but increase is very slow and steady. Figure 4.8 showing the curve of gross irrigated area and trend value of second degree curve and logistic curve. Both the curve of gross irrigated area and the second degree curve run very close to each other. But the logistic curve reveals the upward trend and becomes very close to second degree curve and actual curve which indicates that process of diffusion of gross irrigated area follows the actual curve very closely and logistic curve from 1983 and onwards. The result of coefficient of correlation also proves those same facts. The value of second degree curve and logistic curve is 0.6843 and 0.4975 respectively.

Meerut

Table 4.9 indicates the values of gross irrigated area and the trend value of second degree and logistic curve, during more than two decades of the study area. There has been gradual increase in gross irrigated area with minor fluctuation. Figure 4.9 showing the curves of actual gross irrigated area, second degree and logistic curves which reveals that both the actual and second degree curve run in close proximity with each other while the logistic curve follows the same pattern after 1980 and onwards. The closer view of the trends of these lines shows that the line of actual gross irrigated area mostly follows the pattern of the line of second degree curve. The result of coefficient of correlation also gives the same pattern.

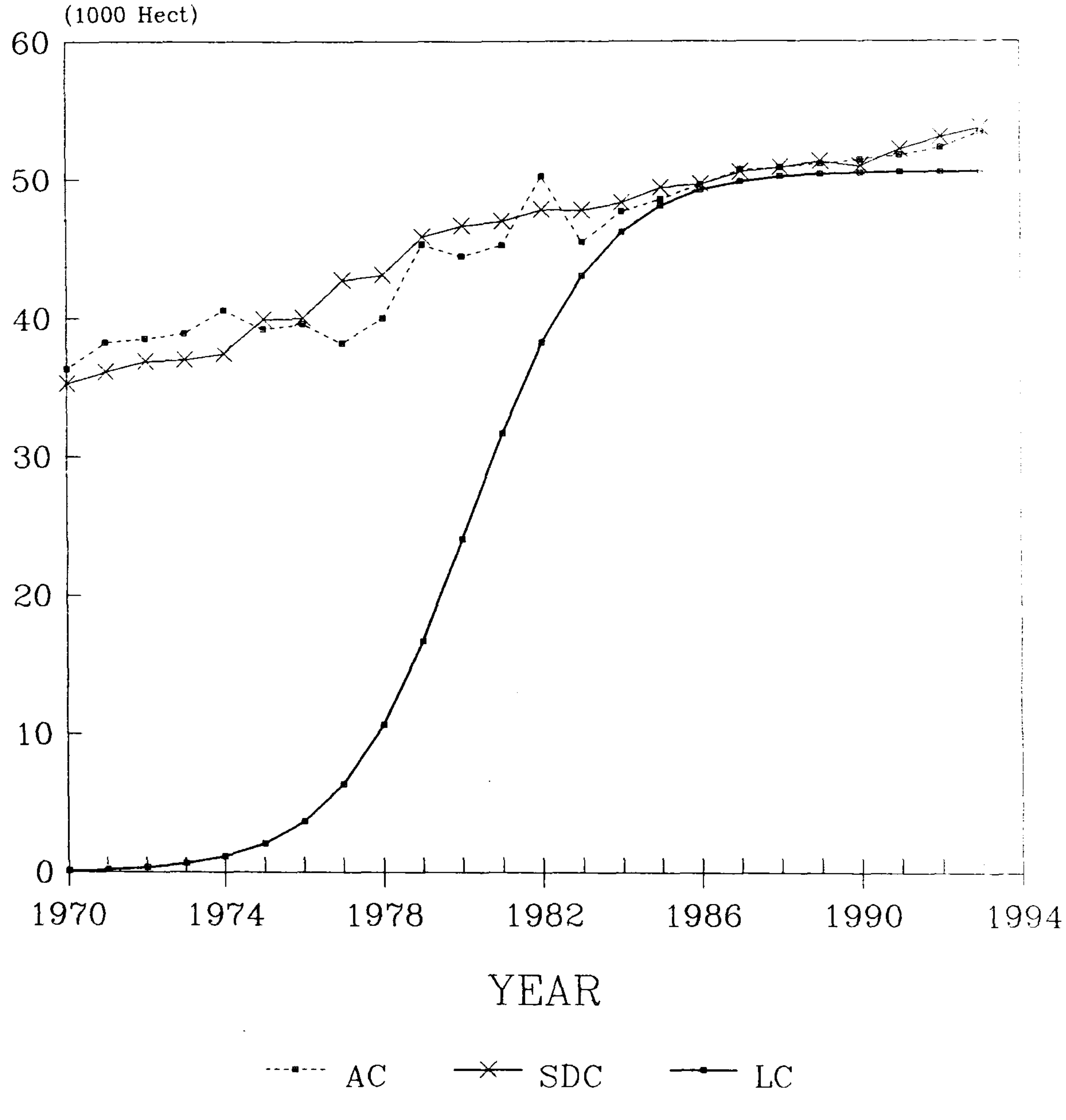
MUZAFFARNAGAR
TREND OF DIFFUSION OF GROSS IRRIGATED AREA (1970-94)



AC : ACTUAL CURVE
SDC : SECOND DEGREE CURVE
LC : LOGISTIC CURVE

Fig. 4.8

MEERUT
TREND OF DIFFUSION OF GROSS IRRIGATTED AREA (1970-94)



AC : ACTUAL CURVE
SDC : SECOND DEGREE CURVE
LC : LOGISTIC CURVE

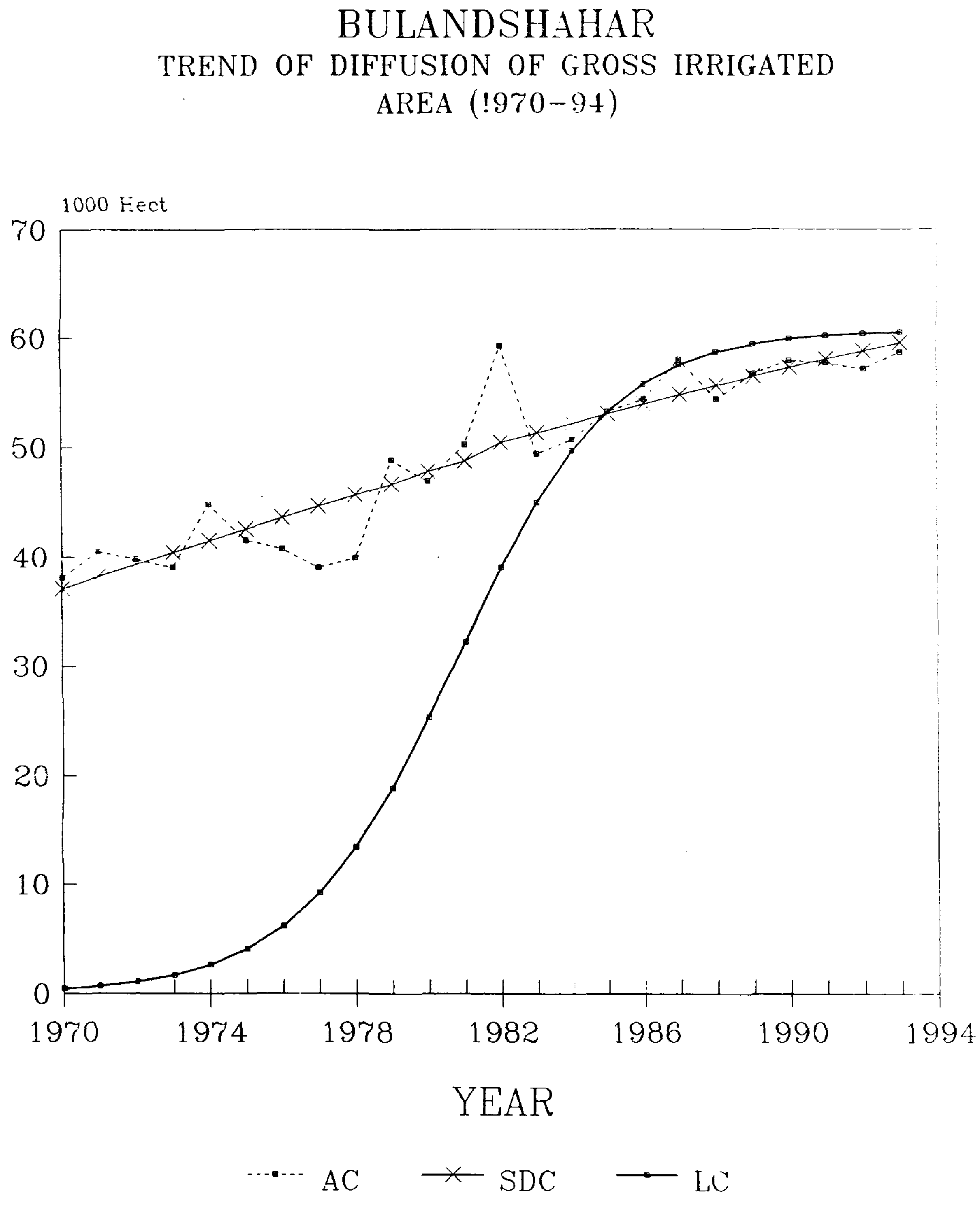
Fig. 4.9

Bulandshahr

Table 4.10 indicates the value of gross irrigated area and value of second degree and logistic curve. During course of the study the rate of irrigated area is continuously increasing but in slow space. Figure 4.10 shows the curves plotted with the help of actual gross irrigated area and computed values of second degree and logistic curves. The two trend values actual and second degree curve run close to each other but with minor fluctuation, where as the logistic curves shows the upward trend and becomes very close to both the curves and runs almost very closely to one an other after 1983. However, actual curves moves much closer to the second degree curve as compare to the logistic curve since 1970 to 1983 and there after all the curves follows the same patterns and run close to one another. Therefore, it indicates the diffusion of gross irrigated area has followed the trend of second degree curve .The result of the coefficient of correlation also prove the same facts.

Ghaziabad

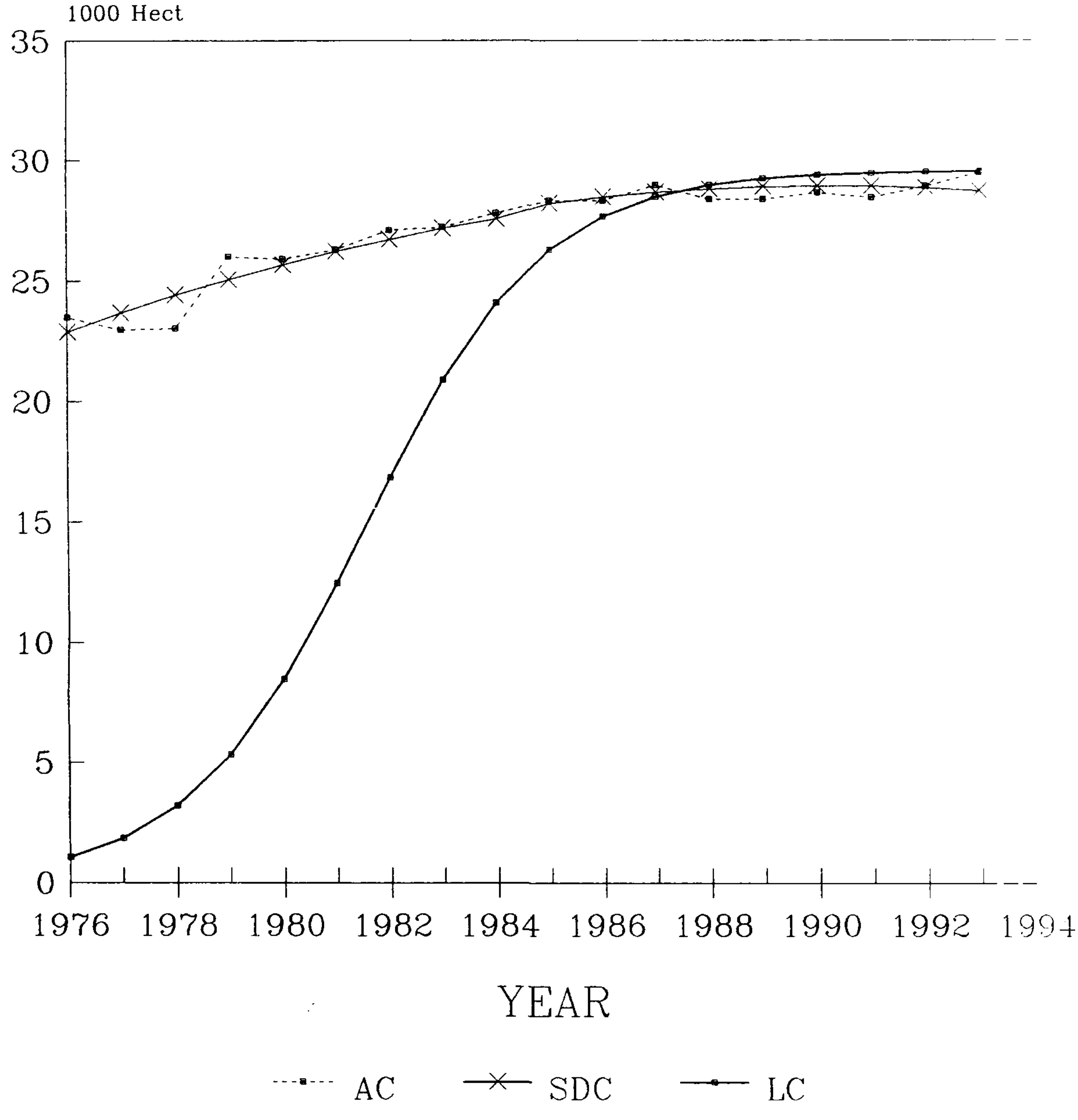
Table 4.11 shows the value of actual gross irrigated area and the values of second degree and logistic curve. During almost two decades of the study of the district indicates the steady growth of gross irrigated area upto 1984-85 and there after the irrigation becomes almost constant. This is attributed to the facts that due to speculation most of the unirrigated area lying close to urban fringe are brought under urban land use and industrial development. Therefore, the irrigation is almost limited to the irrigated area and has no prospects for expansion to unirrigated area for agricultural development, because of non-remunarative as compared to land speculation. Figure 4.11 shows the curve of actual gross irrigated area and the second degree and logistic curve. Both the curves, second degree and actual show the same pattern and runs very close to each other where as logistic curve also follows the same pattern



AC : ACTUAL CURVE
SDC : SECOND DEGREE CURVE
LC : LOGISTIC CURVE

Fig. 4.10

GHAZIABAD
TREND OF DIFFUSION OF GROSS IRRIGATED AREA (1976-94)



AC : ACTUAL CURVE
SDC : SECOND DEGREE CURVE
LC : LOGISTIC CURVE

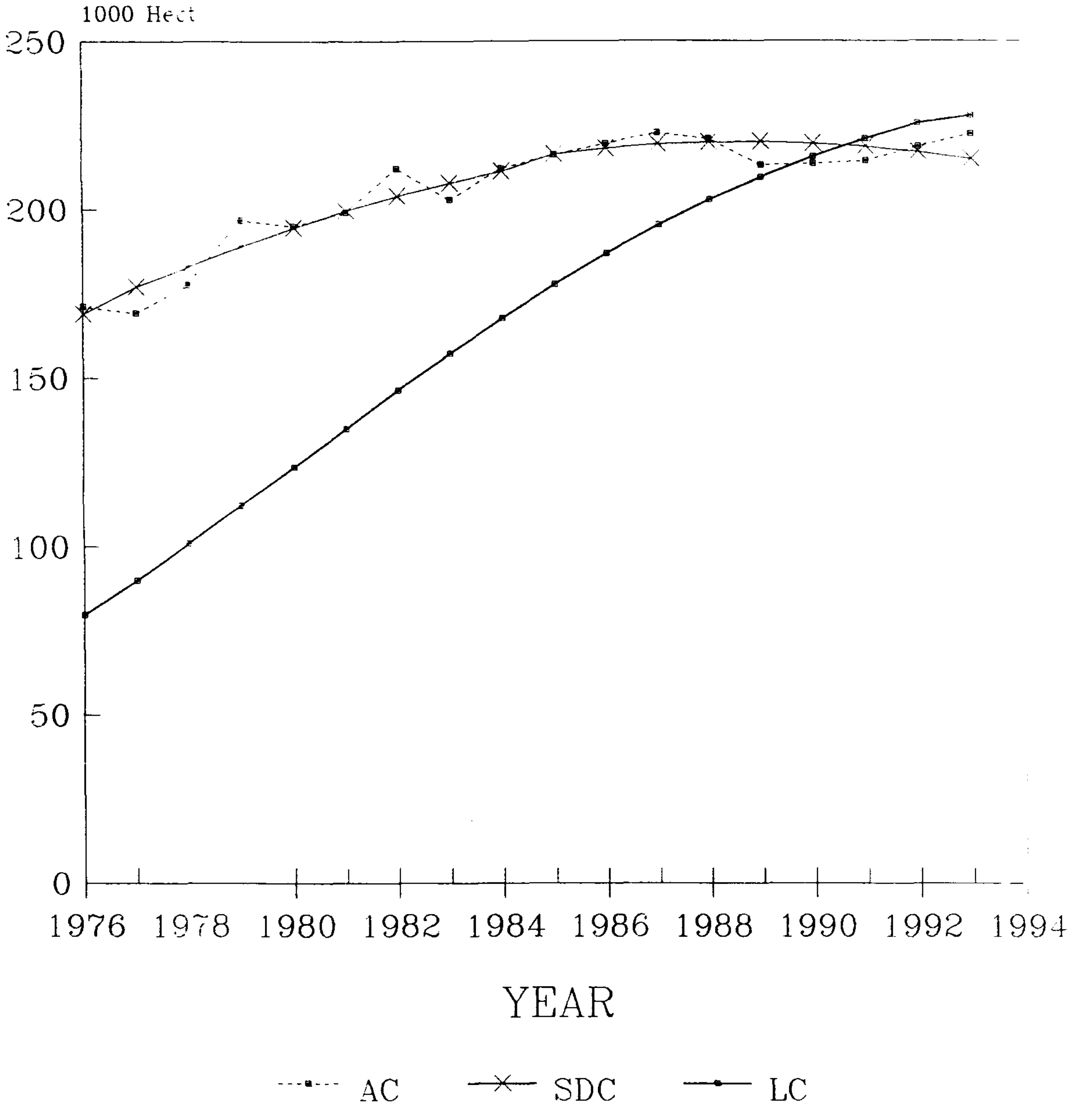
Fig. 4.11

after 1985 and onwards. Since all the three curves actual, second degree and logistic run very close to one another and follows the same trend, which indicates the process of diffusion of gross irrigated area follows both the curves.

Upper Ganga-Yamuna Doab

After the analysis of diffusion of innovations of gross irrigated area in each district of Upper Ganga-Yamuna Doab. It is found that the process of diffusion of gross irrigated area and the fertilizer consumption follows the trend value of second degree curve. It is worthwhile to examine the trend of diffusion of gross irrigated area like fertilizer consumption in Upper Ganga-Yamuna Doab as a whole to test whether it is in accordance with the trend of individual district or not. However, it is important to mention that the period study of Upper Ganga-Yamuna Doab starts from 1976-77 where as the period of study of individual districts begins from 1970-71 except Ghaziabad district because it came into existence in 1976. Therefore, it is desirable and appropriate to study the diffusion of gross irrigated area and fertilizer consumption in Upper Ganga-Yamuna Doab since 1976 onwards. Table 4.12 shows that there is overall increase in gross irrigated area from 1976-77 to 1993-94. Figure 4.12 exhibits the trend line of actual gross irrigated area and computed values of second and logistic curve. The trend lines of actual and second degree curve runs very close to each other since the beginning to an end where as the logistic curve shows the upward trend and becomes very close to the curve after 1988 and further follows the same trend line. And therefore, it may be concluded that diffusion of gross irrigated area in Upper Ganga-Yamuna Doab as whole follows second degree curve which is in accordance with the findings of individual districts.

UPPER GANGA YAMUNA DOAB
TREND OF DIFFUSION OF GROSS IRRIGATED AREA (1976-94)



AC : ACTUAL CURVE
SDC: SECOND DEGREE CURVE
LC : LOGISTIC CURVE

Fig. 4.12

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CHAPTER V

LEVEL OF DIFFUSION OF INNOVATIONS: A SPATIO-TEMPORAL ANALYSIS

LEVELS OF DIFFUSION OF AGRICULTURAL INNOVATIONS: A SPATIO-TEMPORAL ANALYSIS

The process by which an innovation spreads within a social system is called 'diffusion'. An innovation however diffuses within a social system through its 'adoption' by individual and groups. Diffusion and adoption are thus closely interrelated even though they are conceptually distinct.

Most agricultural innovations manifest a material which includes improved implements, variety and extent of use of improved seeds, high yielding of varieties, fertilizers, irrigation techniques, use of pesticides and insecticides to control the number of pests and diseases and new farming practices. Some innovations manifest themselves in behavioural forms such as improved cultural practices. The proper combination of these technological factors ensures high agricultural productivity.

The objective of the present study is to examine the level of diffusion of innovation taking into account three major variables, which are as follows:

(i) different source of irrigation,

(ii) fertilizers consumption,

(iii) modern agricultural implements.

However, the high yielding varieties of seeds are very important regarding the diffusion of innovation. In the present analysis high yielding variety of seeds has been considered hundred percent adoption in the study area. Therefore, it does not make any significance in the study of spatial diffusion of innovations. For the analysis of level of diffusion of innovation Z score statistical technique has been used, which explains:

$$Z = \frac{x - \bar{x}}{S.D}$$

The Z score of each variable has been calculated separately and then it has been made composite Z score, based on three years moving average. The following discussion of each variable are in sequent manner.

Irrigation

Irrigation is indeed the life-breath of agriculture. Agricultural productivity is greatly depends on the availability of water, its proper use and management. Amongst the quick yielding inputs responsible for accelerating agricultural productivity during the short period, assured 'irrigation' facilities not only help in increasing productivity but their availability is a pre-condition for application of other inputs. Due to this reason, in the re-vitalised agricultural production programme, the use of high yielding variety of seeds, together with the high doses of fertilizer, has been inextricably linked with assured water resources either through reliable natural rain water or through artificial irrigation[1]. Experiments conducted at various research centres for appraisal of the joint requirements of crucial inputs for attaining optimum crop yields, irrigation factor has been identified to be one of the most important factors[2]. Irrigation is not only essential for sustenance of agriculture but also its assured and timely supply is a pre-requisite for diversifying agriculture and for enhancing resource-efficiency of related inputs[3]. In fact, it is the 'linkage' aspect of irrigation resource, which serves as a beverage for the agricultural development under the new strategy[4]. Irrigation can thus be the key input, offering the possibility of the greatest increase in the value of production, particularly when used in an appropriate combination with other inputs[5].

Indian agriculture is the gamble of mansoon, which is characterised by erratic and uncertainty of rainfall, besides high variability of the rainfall is a common phenomenon. Therefore, adequate and assured irrigation is very necessary for higher agricultural productivity together with other inputs which includes chemical fertilizers, high yielding variety of seeds and use of pesticides, insecticides, fungicides etc.

The Upper Ganga-Yamuna Doab has a vast reservoir of surface and ground water, fertile soil and better climatic condition. The perennial river of the Ganga system drains this region. The vast level plain and gentle slope provides easy base for the construction and development of the canal. The study area received 60 to 70 cm rainfall and more than 90 percent of the rainfall takes place during rainy season, which spans over more than two to three months and rest of the year remains dry. Irrigation thus, is very necessary for the development of agriculture. Though the net irrigated area of the region accounts 97 percent in current year, yet a great variation exists from one region to another. On the basis of Z scores the whole region has been categorised into three major groups i.e., high, medium and low irrigation which are as follows:

High Level of Irrigation:

The high level of irrigation consists of three tehsils, Sikandrabad, Bulandshahr and Khurja (1981) which accounts 95 percent area under irrigation, having an indices varying from +0.5 to –0.5 of Z scores. In 1986 new tehsil is added under high irrigation such as Dadri and now the area has come under 99 percent irrigated of the net sown area. Thus the number of tehsils became four instead of three. In 1991 the picture is different, though the number of the tehsils remains the same but two new tehsils took over the place of Khurja and Dadri, such as Ghaziabad and Anupshahr, and Dadri and Khurja occupied the second place i.e., (medium level of irrigation). Besides the changing position of different tehsils from medium to high and vice-versa the magnitude of irrigation has also changed from 94 percent in 1981 to 100 percent in 1991.

Medium Level of Irrigation:

The medium level of irrigation in 1981 comprises of seven tehsils namely Nakur, Muzaffarnagar, Baghpat, Ghaziabad, Garhmukteswar, Dadri and Anupshahr accounts 87 percent area under irrigation. In 1986 two more tehsils were added which spreads over nine tehsils, viz., Nakur, Deoband, Jansath, Baghpat, Meerut, Ghaziabad and Anupshahr. After five year the area under irrigation has gone up to 90 percent in 1986. Where as in 1991 the percentage of irrigated area has further increased by five percent and number of tehsils under this category was reduced to six from nine, which experiences 95 percent of area under irrigation.

Low Level of Irrigation:

Ten tehsils out of twenty in the study area comes under the low level of irrigation such as Saharanpur, Roorkee, Deoband, Kairana, Budhana, Jansath, Sardhana, Mavana, Meerut and Hapur accounts 80 percent area under irrigation. In 1986 the percentage of area under irrigation has increased by 3 percent from 1981 to 1986 i.e., 80 percent and 83 percent respectively. The number of tehsils were reduced to seven from ten in 1986; viz., Saharanpur, Roorkee, Kairana, Muzaffarnagar, Budhana, Sardhana and Mavana. With the passage of time, the extension of means of transportation and communication and other infrastructure and facilities helped the adoption of innovation, subsequently new area are brought under irrigation. Thus in 1991 the area under irrigation has gone up to 85 percent, comprising of ten tehsils, namely Saharanpur, Nakur, Roorkee, Deoband, Kairana, Muzaffarnagar, Budhana, Jansath, Sardhana and Mvana (Table 5.1 and Figures 5.1 A, B and C).

Table 5.1

Percentage of Different Source of Irrigation

S. No.	1981				1986				1991			
	Total Z-Score				Total Z-Score				Total Z-Score			
	X	$x = (X-\bar{x})$	x^2	Z-Score	X	$x=(X-\bar{x})$	x^2	Z-Score	X	$x=(X-\bar{x})$	x^2	Z-Score
1	-1.40	-1.42	2.02	-0.65	-1.56	-1.79	3.2	-0.86	-1.42	-1.48	2.19	-0.70
2	-0.75	-0.77	0.59	-0.35	+0.64	+0.41	0.17	+0.20	-1.14	-1.20	1.44	-0.57
3	-2.09	-2.11	4.45	-0.97	-1.37	-1.60	2.56	-0.77	-1.30	-1.36	1.85	-0.64
4	-1.55	-1.57	2.46	-0.72	-0.77	-1.00	1	-0.48	-1.01	-1.07	1.15	-0.51
5	+1.58	+1.56	2.43	-0.72	-0.87	-1.10	1.21	-0.53	-1.12	-1.18	1.39	-0.56
6	-0.99	-1.01	1.02	-0.47	-1.58	-1.81	3.28	-0.87	-1.39	-1.45	2.1	-0.68
7	-1.67	-1.69	2.86	-0.78	-1.03	-1.26	1.59	-0.61	-1.33	-1.39	1.93	-0.66
8	-1.41	-1.43	2.05	-0.66	-0.55	-0.78	0.61	-0.38	-1.08	-1.14	1.3	-0.54
9	-0.70	-0.72	0.52	-0.33	-0.44	-0.67	0.45	-0.23	-0.54	-0.60	0.36	-0.28
10	-1.68	-1.70	2.89	-0.78	-1.38	-1.61	2.59	-0.78	-1.12	-1.18	1.39	-0.56
11	-1.23	-1.25	1.56	-0.58	-1.88	-2.11	4.45	-1.02	-1.24	-1.30	1.69	-0.61
12	-1.62	-1.64	2.69	-0.76	-0.08	-0.31	0.1	-0.15	-0.86	-0.92	0.85	-0.43
13	+0.03	+0.01	0.0001	+0.01	-0.57	-0.80	0.64	-0.39	+1.45	+1.39	1.93	+0.66
14	-1.29	-1.31	1.72	-0.60	+0.85	+0.62	0.38	+0.30	-0.55	-0.61	0.37	-0.29
15	-0.46	-0.48	0.23	-0.22	+0.13	-0.10	0.01	-0.05	-0.65	-0.71	0.51	-0.33
16	+0.74	+0.72	0.52	+0.33	+3.89	+3.66	13.40	+1.77	+0.66	+0.60	0.36	+0.28
17	+3.88	+3.86	14.9	+1.78	+7.31	+7.08	50.13	+3.42	+3.12	+3.06	9.37	+1.44
18	+4.88	+4.86	23.2	+2.24	+1.79	+1.56	2.43	+0.75	+5.43	+5.37	28.84	+2.53
19	+0.82	+0.80	0.64	+0.37	+0.59	+0.36	0.13	+0.17	+5.63	+5.57	31.02	+2.63
20	+5.27	+5.25	27.56	+2.42	+1.52	+1.29	1.66	+0.62	-0.36	-0.30	0.09	-0.14

$\bar{x} = 0.018$ SD = 2.17 $\bar{x} = 0.232$ SD = 2.07 $\bar{x} = 0.059$ SD = 2.12

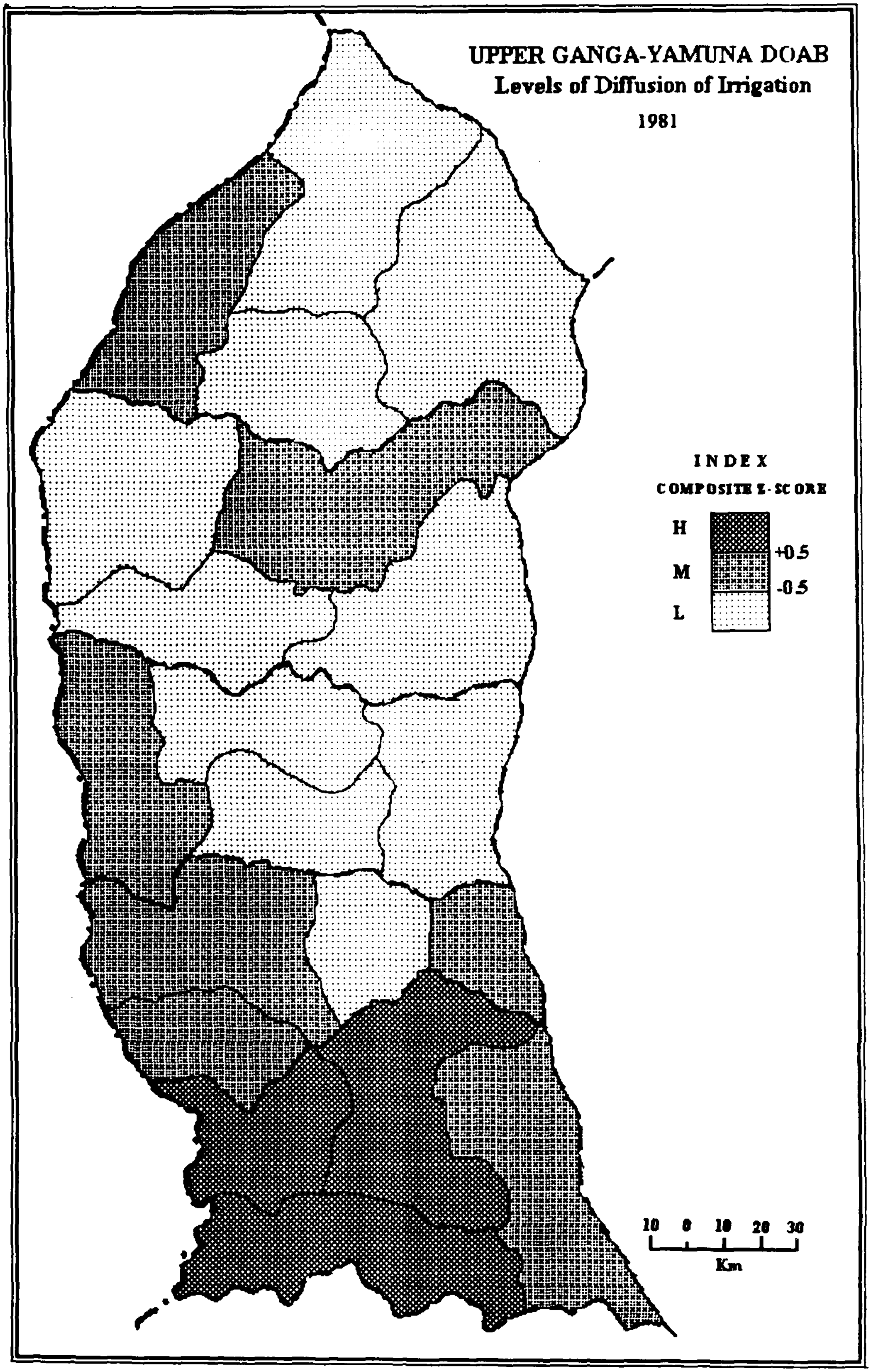

UPPER GANGA-YAMUNA DOAB
Levels of Diffusion of Irrigation
1981
INDEX
COMPOSITE Z-SCORE
H
+0.5
M
-0.5
L
10 0 10 20 30
Km

Fig. 5.1A

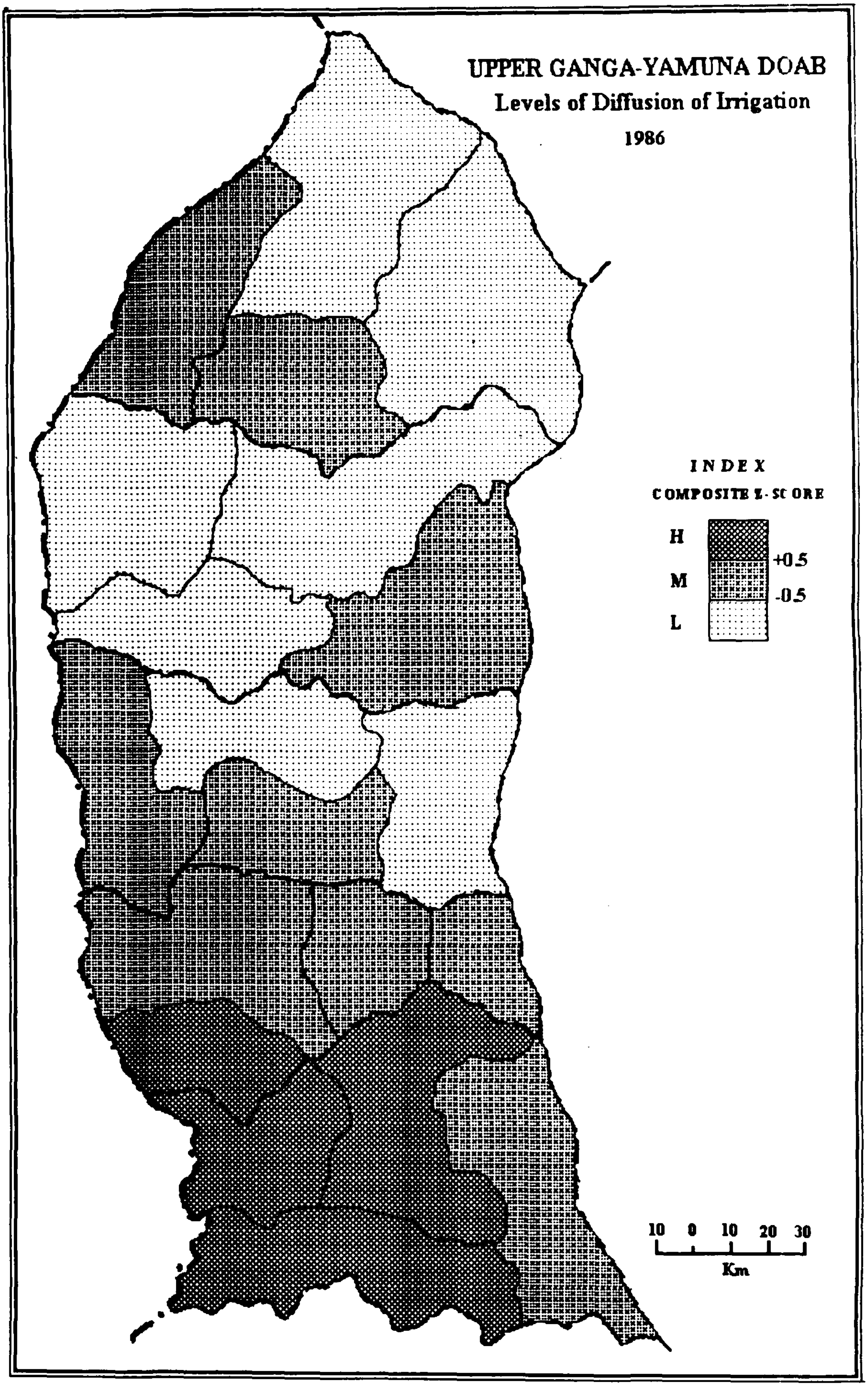

UPPER GANGA-YAMUNA DOAB
Levels of Diffusion of Irrigation
1986
INDEX
COMPOSITE Z-SCORE
H
+0.5
M
-0.5
L
10 0 10 20 30
Km

Fig. 5.1B

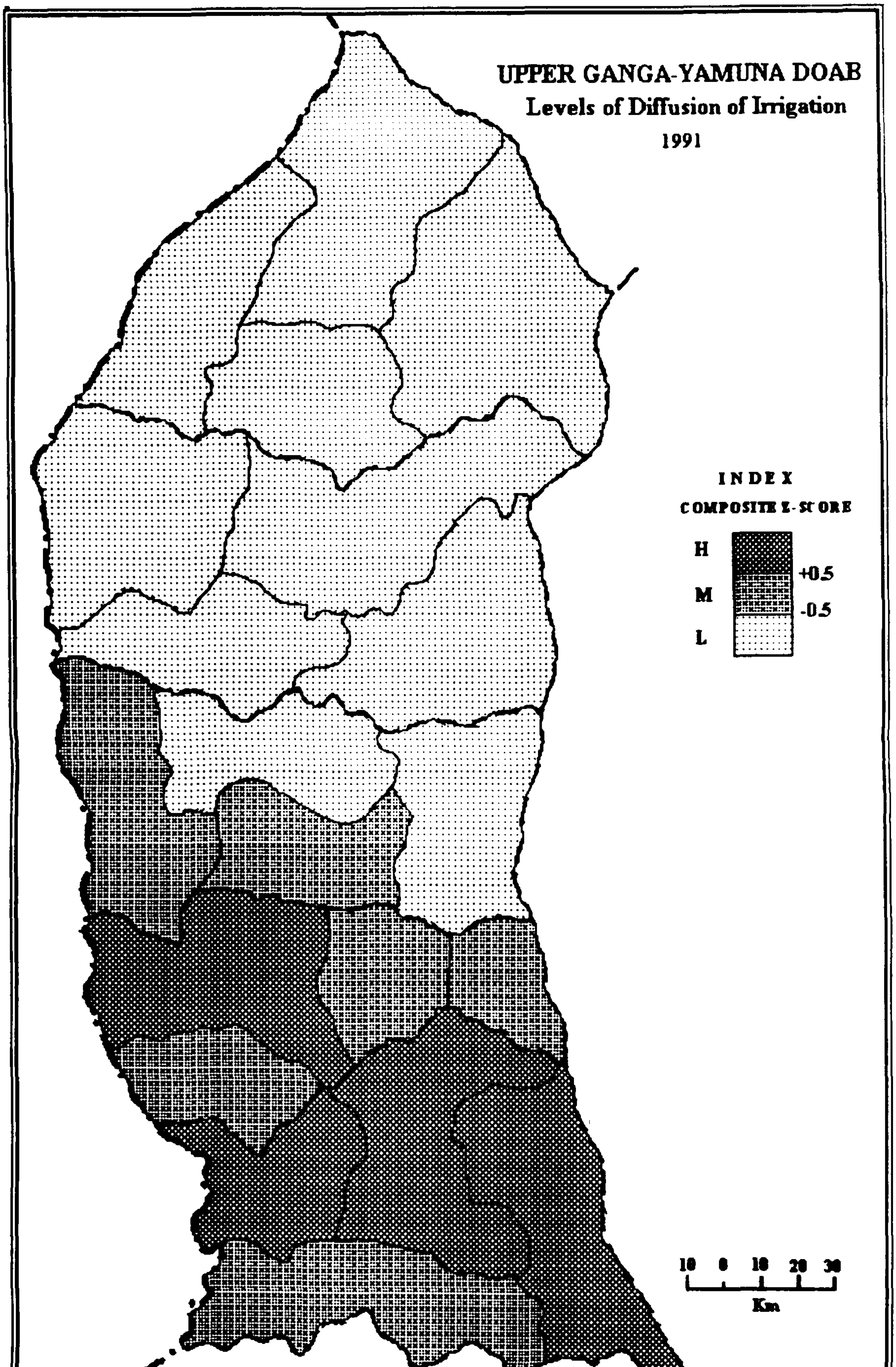

UPPER GANGA-YAMUNA DOAB
Levels of Diffusion of Irrigation
1991
INDEX
COMPOSITE Z-SCORE
H
M
L
+0.5
-0.5
10 0 10 20 30
Km

Fig. 5.1C

Fertilizer

The key to growth in agricultural productivity for short period lies in intensive use of chemical fertilizer. In the new strategy, fertilizer has played the role of kingpin because when soil fertility is low, better germ plasm fail to show postulated yield differentials. The continuous deteriorating soil fertility on account of regular cultivation can also be replenished to a great extent by resupplying nitrogen in the soil through the use of fertilizers, and plant yields can be stepped up by the use of adequate nutrition in the form of fertilizers. Fertilizers can thus play a significant role in providing a major break through in agricultural production.

Researches have revealed the great potentialities for sustained increase in crop production, can be attained through greater and more efficient use of fertilizers and manures. The annual report of FAO states the use of fertilizers as a "spearhead of agricultural development", because wherever efforts are made to raise agricultural efficiency and production for fast increasing population, more fertilizers and manures have invariably needed. Perhaps, even more important, on many soils they make possible good yields of valuable crops that would not grow at all without them, or would grow more poorly[6].

Fertilizers also improve the 'biological quality' and make good the losses of essential nutrients continuously taking place due to cropping, leaching and erosion. In fact, even if all the available organic matter is applied back to the soils, there will still be scope for applications of fertilizers for maintaining it at high level of productivity from year to year[7]. Even during abnormally low rainfall years fertilized crops give higher yields than unfertilized crops.

The reason is that the fertilized crops get good initial start and better development of both root and shoot, which enable them to endure drought to a greater extent than unfertilized crops[8] Due to these reasons, two main planks of the new strategy, viz., multi-cropping, the improved variety of high yielding variety of seeds, have largely been made dependent upon the availability of the required doses of fertilizer input to get satisfactory result.

It may also be emphasized here that the continuous use of chemical fertilizers reduces the humus content of the soil. In the absence of humus, the physical structure of soil undergoes vast changes, and the characteristics of soil and its water holding and absorbing capacity is lost. Substitution by organic manure, therefore, it is imperative which may replace the desirable physical and biological properties to the soil.

The country like India where the population is growing at alarming rate and there is little hope to extend the cultivated land but to improve their productivity is an alternative to feed our tillions through the use of high doses of fertilizers per hectare, high yielding variety of seeds and assured irrigation.

The Upper Ganga-Yamuna Doab experienced green revolution comparatively earlier than other parts of the region of Uttar Pradesh. The consumption of fertilizers is determined by availability of assured irrigation, high yielding variety of seeds, better economic conditions of the farmers, social awareness and high literacy rate. The study area is manifested with varying physico-cultural and socio-economic conditions, thus it is obvious to have varying degree of consumption of fertilizer at spatio-temporal level. Thus, it is seen from the date that it accounts, 99kg per hectare in 1981, 100kg per hectare in 1986 and 112 kg per hectare in 1991. The consumption of fertilizers in spatial context is also not uniform, it subject to vary from place to place depending upon ecological setting of the area. The study area has been grouped into three categories such as high, medium and low level of consumption of fertilizers.

High Level of Consumption of Fertilizers

The high level of consumption of fertilizers with indices above +0.5 score value, comprises of Deoband, Jansath, Sardhana, Mavana, Meerut and Anupshahr. The average consumption of fertilizer is 129kg per hectare 1981. The average consumption of fertilizer in 1986 goes 131.33 kg per hectare comprising of six tehsils such as Deoband, Sardhana, Mavana, Meerut, Hapur and Garhmuktswar. Where in 1991 the average consumption of fertilizer has increased to 135 kg per hectare, comprises of nine tehsils such as Deoband, Kairana, Muzaffarnagar, Budhana, Sardhana, Meerut, Hapur and Garhmukteswar.

Medium Level of Consumption of Fertilizers

The medium level of consumption of fertilizers with the indices ranging from +0.5 to -0.5 score value, which comprises ten tehsils in 1981, such as Saharanpur, Nakur, Roorkee, Kairana, Muzaffarnagar, Budhana, Baghpat, Hapur, Garhmukteswar and Bulandshahr. The average consumption of fertilizers is 95.07 kg per hectare which accounts 83.5 percent area under irrigation and experienced 39.42 percent literates. In 1986 it comprises of nine tehsils such as Nukur, Roorkee, Kairana, Muzaffarnagar, Budhana, Jansath, Baghpat, Ghaziabad and Anupshahr. The average consumption of fertilizers is 97 kg per hectare, it accounts 87.48 percent area under irrigation and experienced 40.06 percent literacy in the region. Where as in 1991 the number of tehsils reduced to five such as Nakur, Jansath, Baghpat, Mavana, and Bulandshahr.

The average consumption of fertilizer is about 119 kg per hectare. The irrigated area is 94.21 percent and the literacy rate is 42.07 percent.

Low Level of Consumption of Fertilizers

The low level of consumption of fertilizers with the indices below -0.5 Z score value, which comprises of four tehsils in 1981, such as Ghaziabad, Dadri, Sikandrabad and Khurja. The average consumption of fertilizers is about 60 kg per hectare in 1981. The irrigation under this category is 90.36 percent and literacy rate is 39.23 percent in 1981. In 1986 it includes five tehsils such as Saharanpur, Dadri, Sikandrabad, Budhana and Khurja. The average consumption of fertilizer is 75.36 kg per hectare in 1986. In 1986 the area under irrigation is 96.68 percent and literacy rate is 40.10 percent. In 1991 it comprises of six tehsils, namely Roorkee, Ghaziabad, Dadri, Sikandrabad, Anupshahr and Khurja. The average consumption of fertilizer in 1991 is 80 kg per hectare. The rate of irrigation and literacy rate in 1991 is 92.21 percent and 41.07 percent respectively (Table 5.2 and Figures 5.2 A, B and C).

Implements

The primary effect of improved mechanical technique is to save labour but at the same time they do contribute in changing the per hectare yield by introducing new technology. Mechanisation of agriculture has resulted in increased agricultural productivity and reduction of cost. By mechanisation we mean the replacement of animal and human power by machinery where ever it is possible, ploughing is to be done by tractor, sowing and putting of fertilizers by the drill, reaping and threshing by the combined harvesters, threshers and so on. Machines work faster and accurately, than man by himself produces very little but with the help of the machines one can produce much more.

The use of modern implements in Upper Ganga-Yamuna Doab is better than other parts of the region. Mechanisation is affected by size of landholding, economic-position, social status, literacy and exposure to mass media and social awareness etc. Size of land

Table 5.2

Total Consumption of Fertilizer in Kg/hect.

S. No.	1981				1986				1991			
	X	$x=(X-\bar{x})$	x^2	Z-Score	X	$x=(X-\bar{x})$	x^2	Z-Score	X	$x=(X-\bar{x})$	x^2	Z-Score
1	90.7	-7.63	58.22	-0.33	79.89	-22.40	501.76	-1.08	132.87	+17.69	312.94	+0.68
2	95.48	-2.85	8.12	-0.12	94.5	-7.79	60.68	-0.37	121.83	+6.65	44.22	+0.26
3	86.78	-11.55	133.4	-0.49	109.73	+7.44	55.35	+0.36	75.22	-39.96	1596.8	-1.54
4	125.11	+26.78	717.17	+1.14	113.04	+10.75	115.56	+0.52	128.81	+13.63	185.78	+0.53
5	105.03	+6.7	44.89	-0.29	108.46	+6.17	30.07	+0.3	139.52	+24.34	592.44	+0.94
6	87.91	-10.42	108.58	-0.44	97.74	-4.55	20.7	-0.22	130.43	+15.25	232.56	+0.59
7	95.01	-3.32	11.02	-0.14	99.5	-2.79	7.78	-0.13	136.77	+21.59	466.13	+0.83
8	112.85	+14.52	210.83	+0.62	102.62	+0.33	0.1098	+0.02	114.29	-0.89	0.7921	-0.03
9	87.4	-10.93	119.46	-0.47	91.97	-10.32	106.5	-0.5	127.34	+12.16	147.87	+0.47
10	120.66	+22.33	498.63	+0.95	131.17	+28.88	834.05	+1.39	131.61	+16.43	269.94	+0.63
11	126.24	+27.91	778.97	+1.19	112.98	+10.69	114.28	0.51	109.56	-5.62	31.58	-0.22
12	145.56	+47.23	2230.67	+2.01	135.03	+32.74	1071.91	+1.57	130.27	+15.09	227.71	+0.58
13	75.73	-22.6	510.76	-0.96	107.01	+4.72	22.28	+0.23	97.82	-17.36	301.37	-0.67
14	91.2	-7.13	50.84	-0.3	127.78	+25.49	649.74	+1.22	162.7	+47.52	2258.15	+1.84
15	92.26	-6.07	36.84	-0.26	133.97	+31.68	1003.62	+1.52	138.6	+23.42	548.5	+0.91
16	48.14	-50.19	25.19	-2.14	59.3	-42.99	1848.14	-2.06	70.45	-44.73	2000.77	-1.73
17	65.04	-33.29	1108.22	-1.42	78.78	-23.51	552.72	-1.13	77.3	-37.88	1434.89	-1.46
18	108.97	+10.64	113.21	+0.45	86.5	-15.79	249.32	-0.76	115.41	+0.23	0.0529	+0.0001
19	132.6	+34.27	1174.43	+1.46	110.31	+8.02	64.32	+0.39	96.52	-18.66	348.2	-0.72
20	73.85	+24.48	599.27	-1.04	65.46	-36.83	1356.45	-1.77	66.19	-48.99	2400.02	-1.89
	$\bar{x}$ = 98.33		SD = 23.49		$\bar{x}$ = 102.29		SD = 20.82		$\bar{x}$ = 115.18		SD = 25.89	

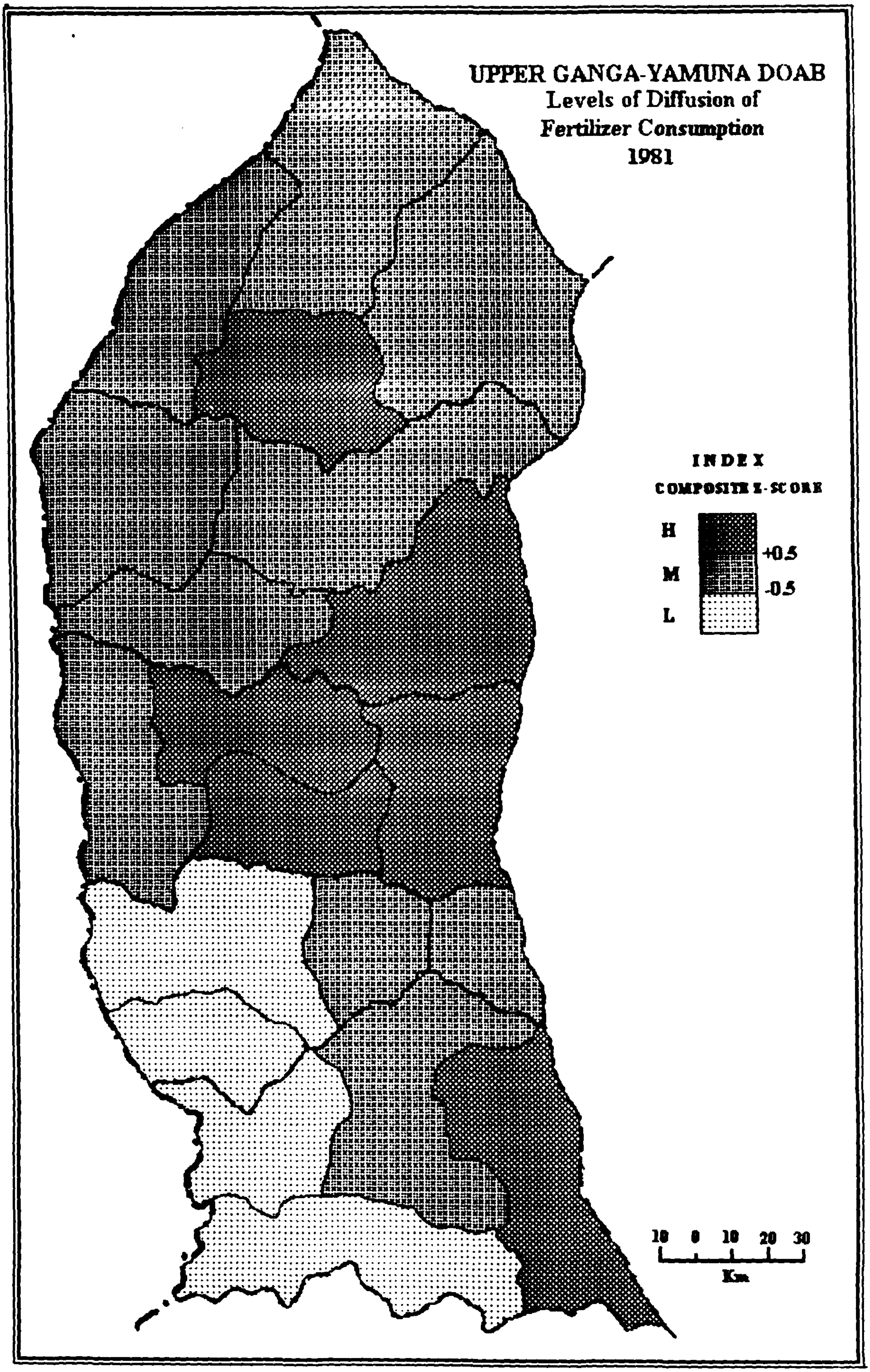

UPPER GANGA-YAMUNA DOAB
Levels of Diffusion of
Fertilizer Consumption
1981
INDEX
COMPOSITE Z-SCORE
H
M
L
+0.5
-0.5
10 0 10 20 30
Km

Fig. 5.2A

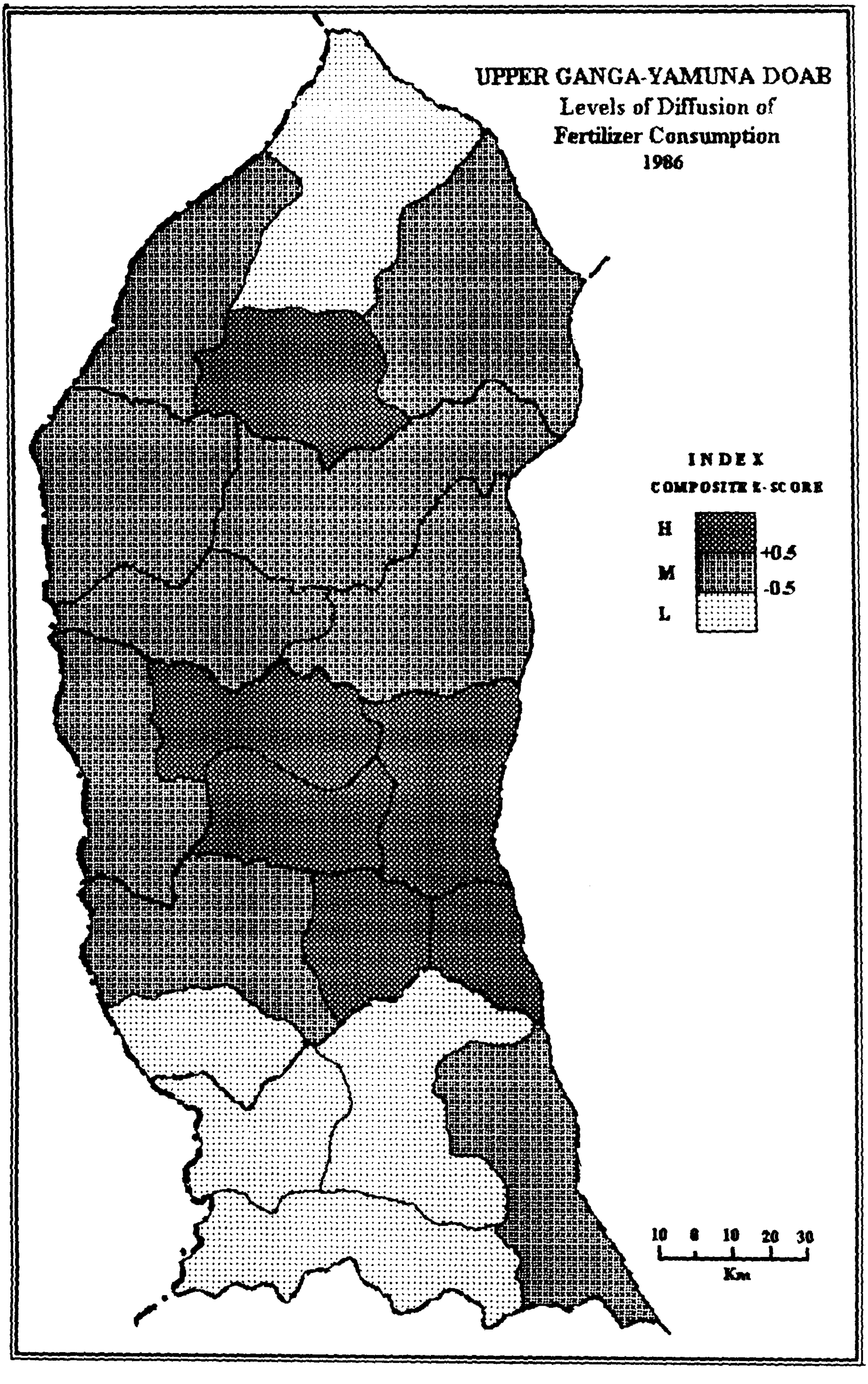

UPPER GANGA-YAMUNA DOAB
Levels of Diffusion of
Fertilizer Consumption
1986
INDEX
COMPOSITE Z-SCORE
H
+0.5
M
-0.5
L
10 0 10 20 30
Km

Fig. 5.2B

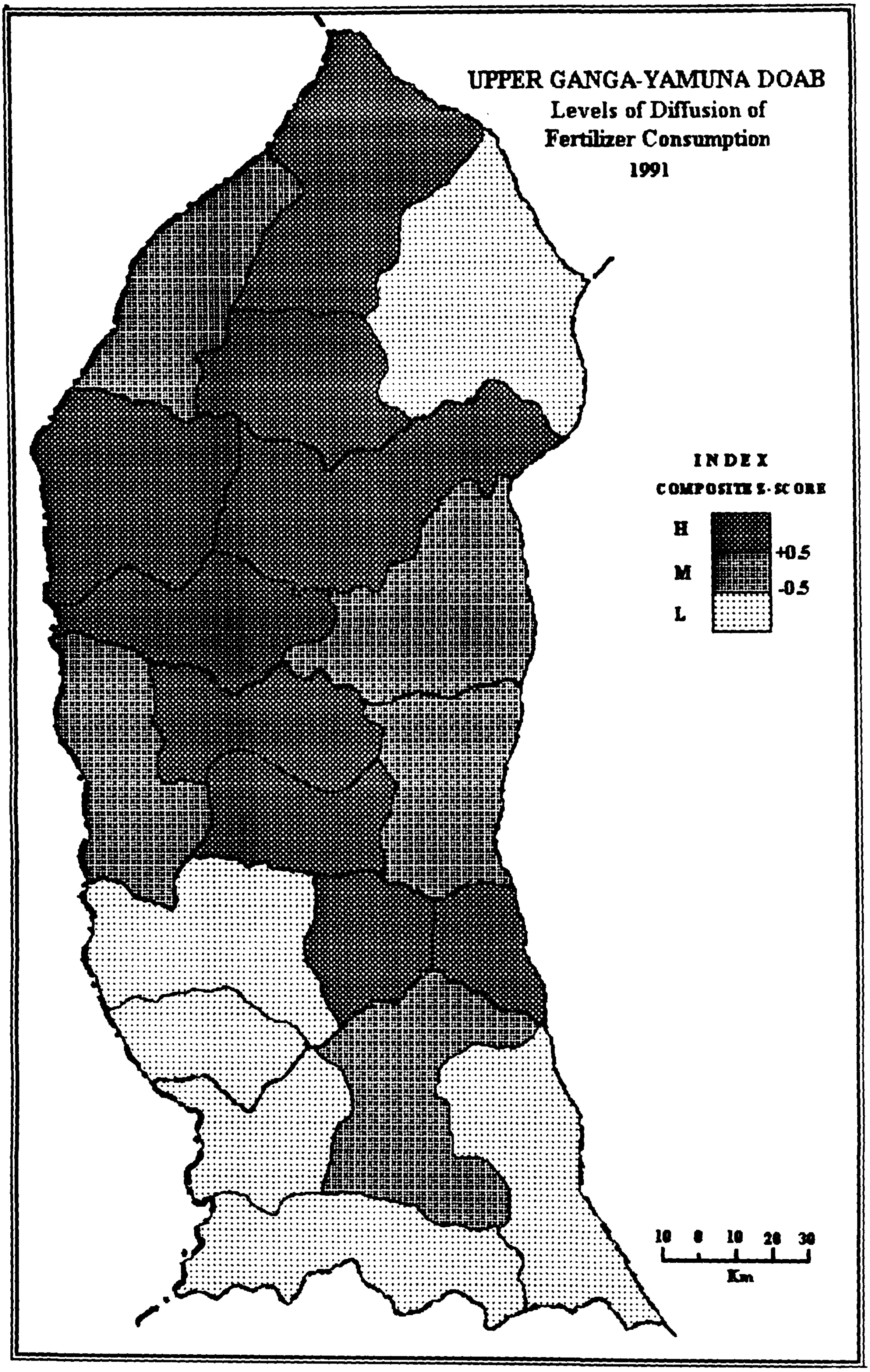

UPPER GANGA-YAMUNA DOAB
Levels of Diffusion of
Fertilizer Consumption
1991
INDEX
COMPOSITE Z-SCORE
H
M
L
+0.5
-0.5
10 0 10 20 30
Km

Fig. 5.2C

holding is one of the important factors, which determines the use of technology to a greater extent. It is evident that there is a positive correlation between the use of agricultural innovations and the size of land holding.

The use of implements in the study area is not uniform but subject to vary in time and space because of diverse ecological setting. Broadly the region has been divided into three major categories based on the level of use of implements such as high, medium and low, which are as follows.

High Level of Use of Implements

The region using high level of implements having indices above +0.5 Z score value comprising of six tehsils in 1981 namely Kairana, Muzaffarnagar, Budhana, Jansath, Ghaziabad and Garhmukteswar. The number of tehsils remains the same but some new tehsils take the position of others. These tehsils are Deoband, Kairana, Muzaffarnagar, Budhana, Jansath and Baghpat, whereas in 1991, again the number remains the same gap such as Saharanpur, Kairana, Muzaffarnagar, Baghpat, Ghaziabad and Hapur, but again new tehsils take the position of others. The above analysis reveals that the number remains almost the same but some of them have got from high to medium and low to medium and high during 1981 to 1991. The changing nature of the position of tehsils may be attributed to the improvement of socio-economics conditions of the farmers.

Medium Level of Use of Implements

The region having medium use of implements with the indices ranging from +0.5 to -0.5 Z score value, comprising of five tehsils in 1981, namely, Nakur, Deoband, Hapur, Dadri and Bulandshahr. In 1986 three more tehsils come under this category excluding of existing five tehsils, and thus the number has increased upto eight. But the position of tehsils has got changed. These tehsils are Nakur, Roorkee, Sardhana, Mavana Meerut, Ghaziabad, Sikandrabad and Anupshahr. Whereas in 1991 it accounts nine tehsils such as Deoband, Budhana, Jansath, Sardhana, Mavana, Meerut, Dadri and Bulandshahr. The medium level of implements is determined with the medium level of size of land holdings, neither too large nor too small and the region experienced the medium literacy rate in increasing order i.e., 43.05 percent to 45.05 percent from 1981 to 1991 respectively.

Low Level of Use of Implements

The region having low use of implements with the indices below +0.5 to -0.5 Z score value which accounts nine tehsils, namely Saharanpur, Roorkee, Baghpat, Sardhana, Mavana, Meerut, Sikandrabad, Anupshahr and Khurja. In 1986 the number of tehsils has not only declined from nine to six, but also two former tehsils has attained the same position under the low level of use of implements, such as Saharanpur and Khurja. In 1991 six tehsils has accupied the position namely Nakur, Roorkee, Garhmukteswar, Sikandrabad, Anupshahr and Khurja (Table 5.3 and Figures 5 3 A, B and C).

After foregoing discussion regarding the level of diffusion of irrigation, consumption of fertilizers and use of implements at tehsil level in Upper Ganga-Yamuna Doab in spatio-temporal context. It may be concluded that the area under irrigation, consumption of fertilizer kg per hectare and the use of implements has steadily increased. It is attributed to the fact that this area has experienced the green revolution on a massive scale. The two variables such as irrigation and consumption of fertilizer are interdependent and co-terminus, meaning thereby the high doses consumption of fertilizer requires, assured irrigation for high productivity besides, the high yielding variety of seeds, chemical fertilizer and assured irrigation to maximise the agricultural

Table 5.3

IMPLEMENTS

	1981				1986				1991			
	Total Z-Score				Total Z-Score				Total Z-Score			
S. No.	X	$x=(X-\bar{x})$	x^2	Z-Score	X	$x=(X-\bar{x})$	x^2	Z-Score	X	$x=(X-\bar{x})$	x^2	Z-Score
1	-2.34	-2.25	5.06	-0.70	-3.57	-3.52	12.39	-1.19	+6.97	+6.91	47.75	+2.69
2	-1.64	-1.55	2.40	-0.48	-0.39	-0.34	0.12	-0.12	-3.02	-3.08	9.49	-1.20
3	-3.33	-3.24	10.50	-1.00	-0.96	-0.91	0.83	-0.31	-1.64	-1.70	2.89	-0.66
4	+0.83	+0.92	0.85	+0.28	+2.23	+2.28	5.20	+0.77	-0.52	-0.58	0.34	-0.23
5	+3.53	+3.62	13.10	+1.12	+4.62	+4.67	21.81	+1.58	1.97	+1.91	3.65	+0.74
6	+5.65	+5.74	32.95	+1.78	+3.08	+3.13	9.80	+1.06	3.64	+3.58	72.82	+1.39
7	+6.35	+6.44	41.47	+1.99	+3.33	+3.38	11.42	+1.15	-0.16	-0.22	0.05	-0.09
8	+4.9	+4.99	24.9	+1.44	+2.91	+2.96	8.76	+1.00	-0.9	-0.96	0.92	-0.37
9	-2.39	-2.3	5.29	-0.71	+6.47	+6.52	42.51	+2.21	+2.35	+2.29	5.24	+0.89
10	-3.3	-3.21	10.3	-0.99	+0.63	+0.68	0.46	+0.23	-0.83	-0.89	0.79	-0.35
11	-3.8	-3.71	13.76	-1.15	+1.14	+1.19	1.42	+0.4	-0.83	-0.89	0.79	-0.35
12	-2.97	-2.88	8.29	-0.89	-0.72	-0.67	0.45	-0.23	-0.56	-0.62	0.38	-0.24
13	+3.87	+3.96	15.68	+1.23	-1.31	-1.26	1.59	-0.43	+4.16	+4.10	16.81	+1.6
14	-0.57	-0.48	0.23	-0.15	-3.28	-3.23	10.43	-1.09	+1.74	+1.68	2.82	+0.65
15	+2.24	+2.33	5.43	+0.72	-2.98	-2.93	8.58	-0.99	-2.98	-3.04	9.24	-1.18
16	-0.31	-0.22	0.05	-0.07	-3.26	-3.21	10.3	-1.09	-0.39	-0.45	0.2	-0.18
17	-2.37	-2.28	5.2	-0.71	-0.53	-0.48	0.23	-0.16	-1.81	-1.87	3.5	-0.73
18	-1.11	-1.02	1.04	-0.32	-3.12	-3.07	9.42	-1.04	-0.88	-0.94	0.88	-0.37
19	-1.85	-1.76	3.1	-0.55	-0.98	-0.93	0.86	-0.32	-2.09	-2.15	4.62	-0.84
20	-3.08	-2.99	8.94	-0.93	-4.28	-4.23	17.89	-1.43	-2.96	-3.02	9.12	-1.18

$\bar{x}$ = - 0.09 SD = 3.23 $\bar{x}$ = - 0.05 SD = 2.95 $\bar{x}$ = 0.06 SD = 2.57

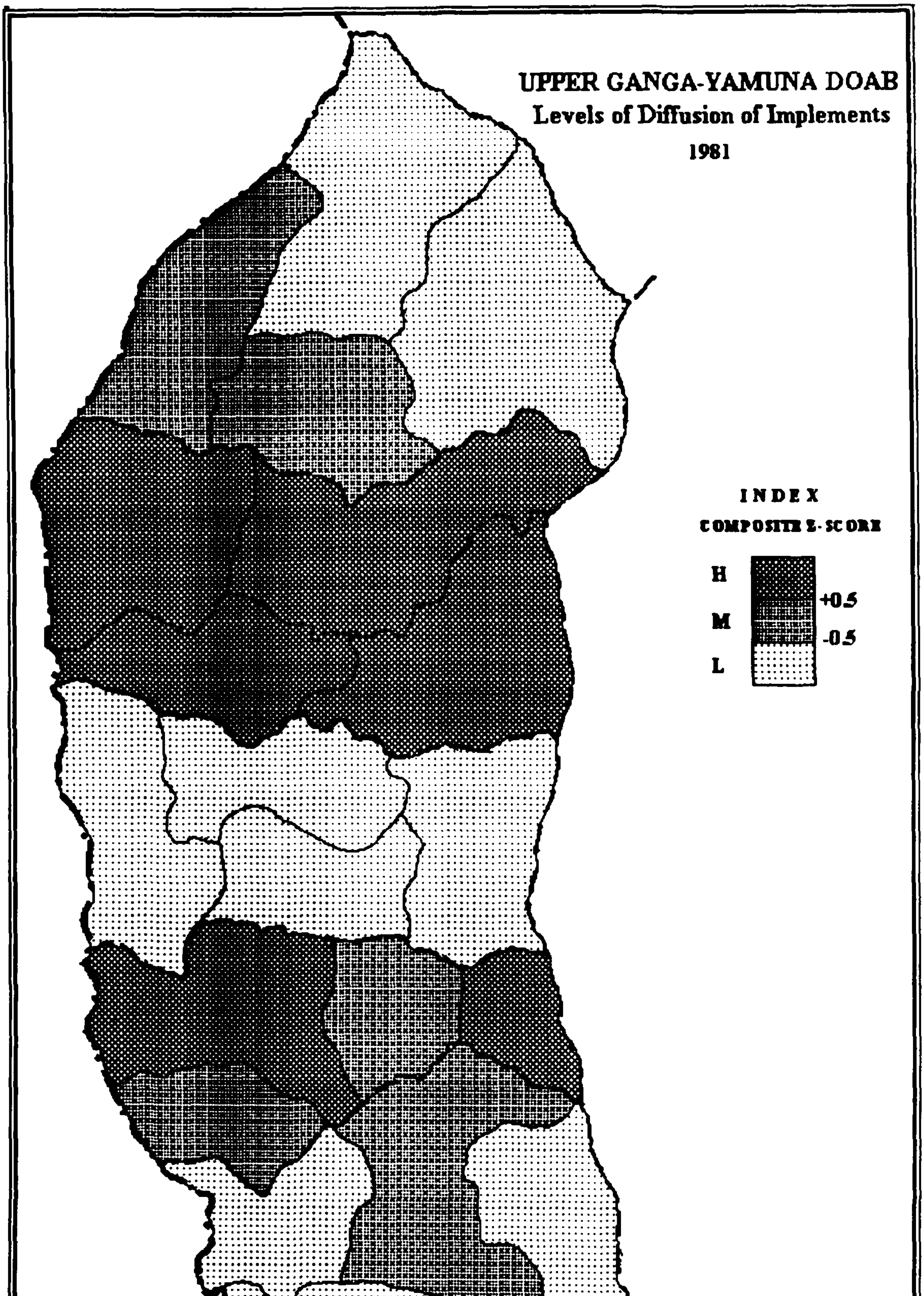

UPPER GANGA-YAMUNA DOAB
Levels of Diffusion of Implements
1981
INDEX
COMPOSITE Z-SCORE
H
+0.5
M
-0.5
L
10 0 10 20 30
Km

Fig. 5.3A

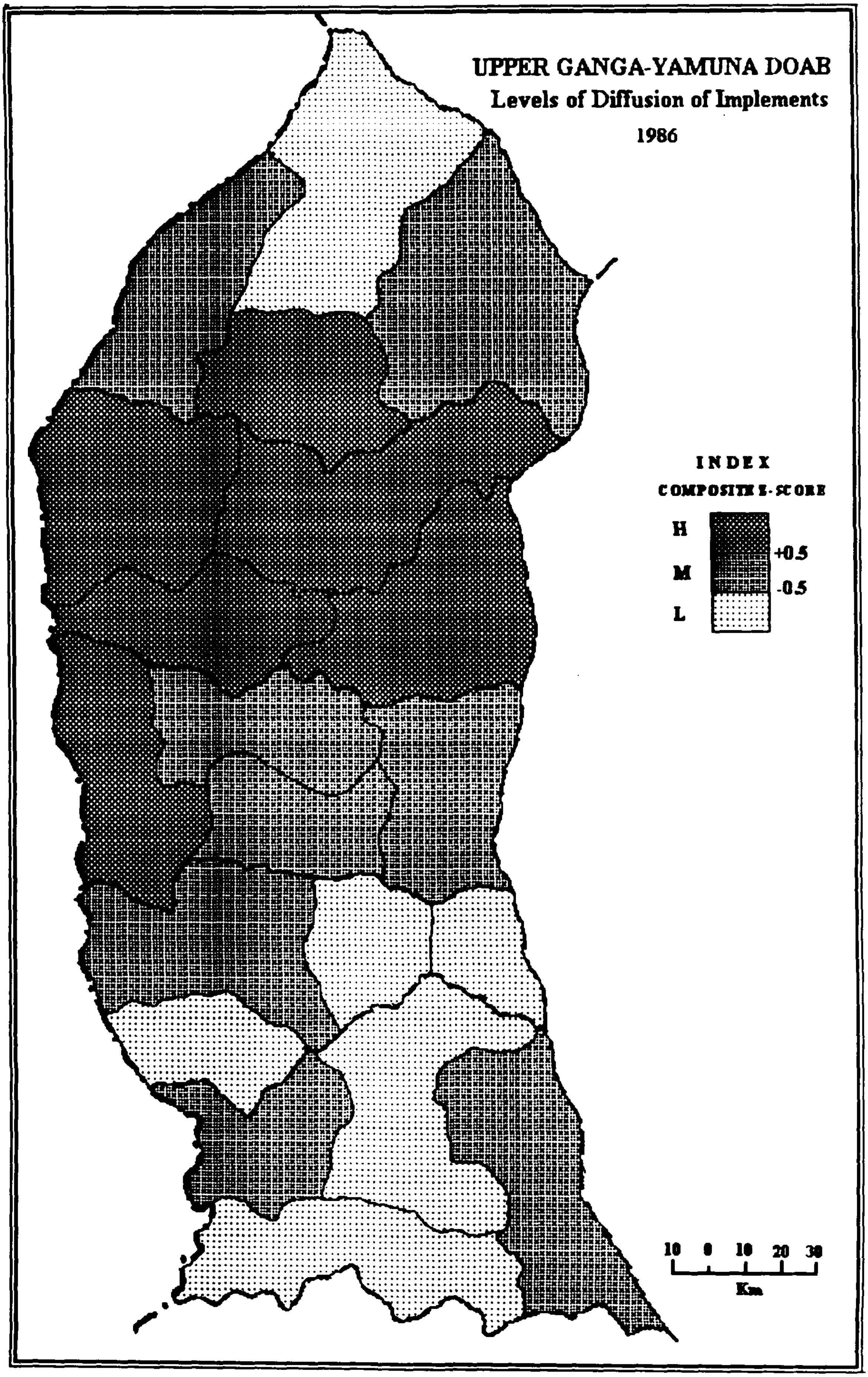
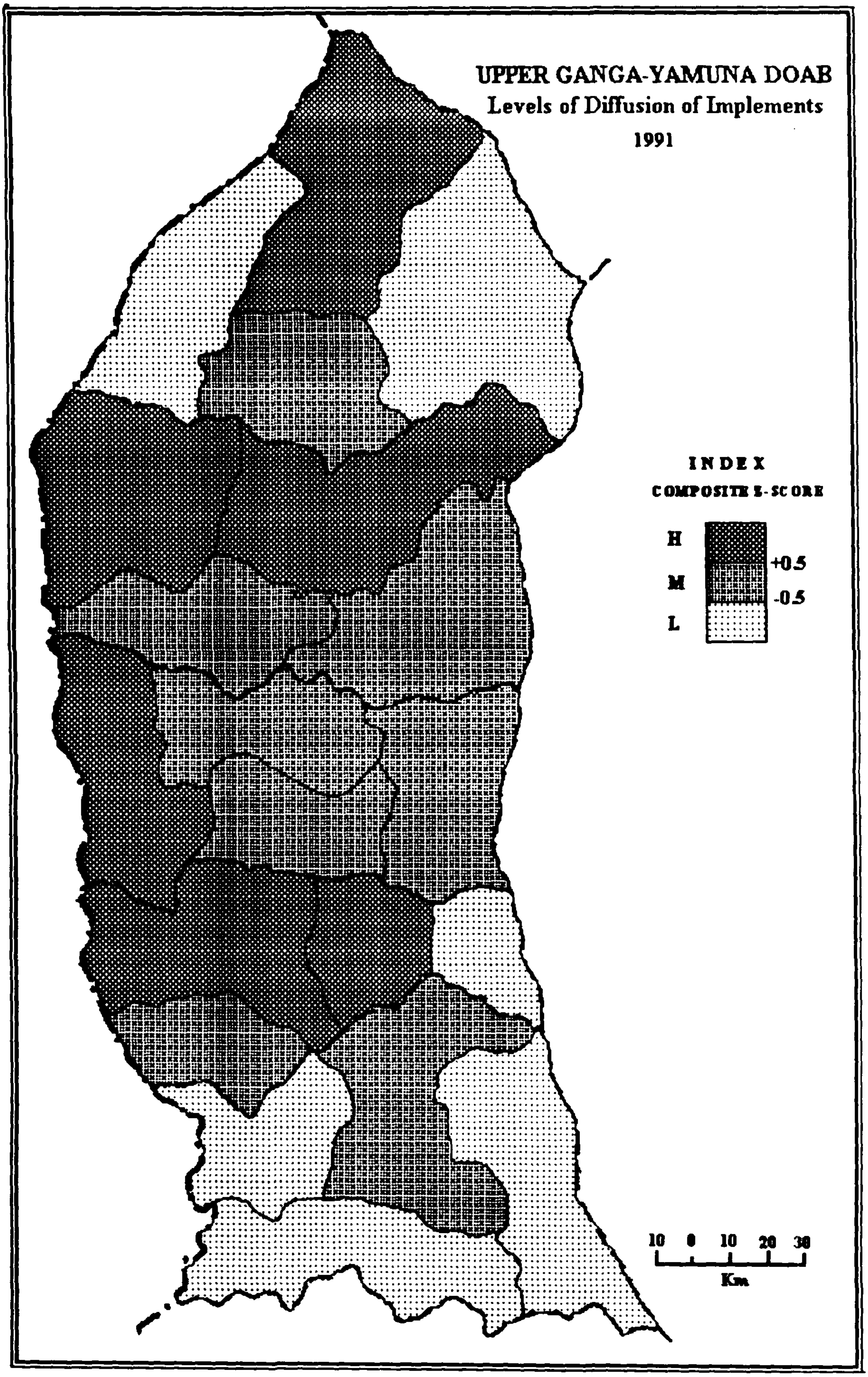

UPPER GANGA-YAMUNA DOAB
Levels of Diffusion of Implements
1986
INDEX
COMPOSITE Z-SCORE
H
M
L
+0.5
-0.5
10 0 10 20 30
Km

Fig. 5.3B


UPPER GANGA-YAMUNA DOAB
Levels of Diffusion of Implements
1991
INDEX
COMPOSITE Z-SCORE
H
M
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+0.5
-0.5
10 0 10 20 30
Km

Fig. 5.3C

productivity. The high level of diffusion of innovations is due to the improved socio- economic condition, literacy rate, exposure to mass media, social awareness, size of family, socio-economic status, size of land holding. Among all the factors irrigation has played dominant role in the increasing trend of consumption of fertilizers. Inhibition about the use of chemical fertilizer has been reduced due to increasing literacy rate in the region and therefore, the consumption of fertilizer has been in increasing trend.

COMPOSITE SCORES OF LEVEL OF DIFFUSION OF INNOVATIONS

The spatio-temporal diffusion of innovations at tehsil level in Upper Ganga-Yamuna Doab has been examined based on composite index of irrigation, consumption of fertilizers, use of implements, which have been discussed above separately. The composite index ranges from +0.5 to -0.5 has been grouped under high, medium and low category and each category has its distinct indices which are discussed in sequent manner.

High Level of Diffusion of Innovations (1981)

The high level of diffusion of innovations comprises of eleven tehsils, namely Saharanpur, Roorkee, Nakur, Deoband, Muzaffarnagar, Budhana, Jansath, Sardhana, Meerut, Ghaziabad and Bulandshahr. The high level of adoption of agricultural innovations are due to the availability of adequate and assured irrigation, social awareness, high density of population, high literacy rate and size of land holding. The level of diffusion of innovations has a direct impact on agricultural productivity. This can be ascertained that most of the tehsils which come under high level of productivity corresponds the high level of diffusion of innovations.

Medium Level of Diffusion of Innovations

This region with indices ranging from +0.5 to -0.5 Z score values, cover five tehsils, namely Kairana, Mavana, Hapur, Garhmukteswar, and Sikandrabad. These tehsils have medium level of adoption of agricultural innovations. The irrigation facilities, consumption of fertilizers and adoption of implements is lower than that of high level of diffusion. The medium category has experienced medium index of literacy and size of land holding as well . The productivity of this region is also lower than that of the area which comes under high productivity region.

Low Level of Diffusion of Innovations

The low level of diffusion of innovations having Z scores less than -0.5 values, consist of four tehsils viz., Baghpat Anupshahr, Khurja and Dadri. The above analysis regarding spatial diffusion of agricultural innovations (1981) has revealed that there is a positive correlation between high literacy index, size of land holding, social awareness, economic status, fertility of the region and diffusion of innovations (Figure 5.4D).

High Level of Diffusion of Innovations (1986)

The high level of diffusion of innovations having indices more than +0.5 values which accounts six tehsils, namely Saharanpur, Deoband, Kairana, Baghpat, Meerut and Sikandrabad. These tehsils have high level of adoption of agricultural innovations. It is due to the fact that these areas are characterised by uniform level plain, fertile soil, better irrigation facilities, bigger size of land holding and better socio-economic conditions of the farmers.

Medium Level Diffusion Innovations

The medium level of diffusion of innovations consists of eight tehsils, namely Nakur, Roorkee, Muzaffarnager, Jansath, Budhana, Mavana, Hapur and Garhmuktswar. The medium levels of diffusion of innovations are caused by relatively slow rate of adoption of new packages of the green revolution. It may be stated that these areas are manifested with low literacy rate and small size of land holding as well as the area under irrigation and other infrastructural facilities are far from satisfactory.

Low Level of Diffusion of Innovations

The low level of diffusion of innovations accounts six tehsils of the study area, namely Sardhana,Ghaziabad, Dadri, Anupshahr, Bulandshshr and Khurja. These tehsils have low adoption of agricultural innovations as compar e to the other regions. The low

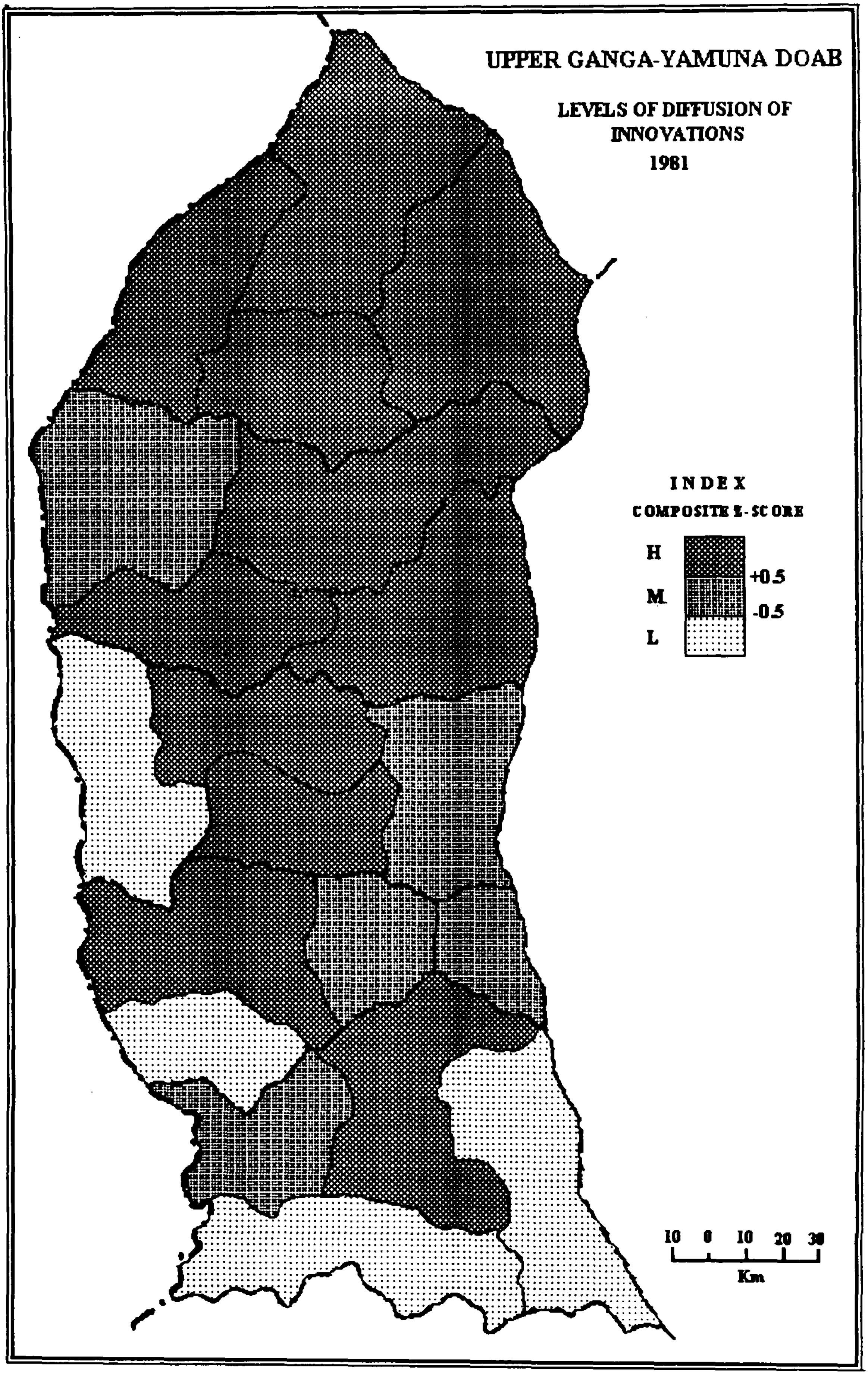
UPPER GANGA-YAMUNA DOAB
LEVELS OF DIFFUSION OF INNOVATIONS
1981
INDEX
COMPOSITE Z-SCORE
H
M
L
+0.5
-0.5
10 0 10 20 30
Km

Fig. 5.4D

level of diffusion of innovations determine poor socio-economic conditions of the region, which has direct bearing on the level of acceptance of new technology and economic transformation (Figure 5.4 E).

High Level of Diffusion of Innovations (1991)

The high level of diffusion of innovations in 1991 comprises of twelve tehsils of Upper Ganga-Yamuna Doab, namely Saharanpur, Roorkee, Nakur, Kairana, Muzaffarnagar, Budhana, Baghpat, Ghaziabad, Hapur, Sikandrabad and Khurja. The indices of scores are more than 0.5 value. It is very interesting to mention here that eleven tehsils which had its position in high level of diffusion of innovations in 1981, has secured their position as such in 1991 except three tehsils, namely Jansath, Meerut and Garhmuktswar. Tehsil Meerut and Garhmuktswar attained the place of medium level of diffusion where as Jansath experienced the low level of diffusion of innovations in 1991. Though more than 80 percent has maintained its position as such. The changing position from high to medium and low includes three tehsils and inclusion of two more tehsils in group of high level of diffusion of innovations in 1991, has come from low and medium group of 1981 i.e., Roorkee, and Kairana respectively. The changing scenario at micro level is due to environmental factors.

Medium Level of Diffusion of Innovations

The medium level of diffusion of innovations in 1991 consists of four tehsils such as Deoband, Sardhana, Meerut and Garhmuktswar. This region is characterised by low literacy i.e., 42 per cent and density of population is 645 persons per square km. The social awareness is relatively low and the size of land holding is also low. Besides the above factors the level of irrigation and the economic status of the people is also not better.

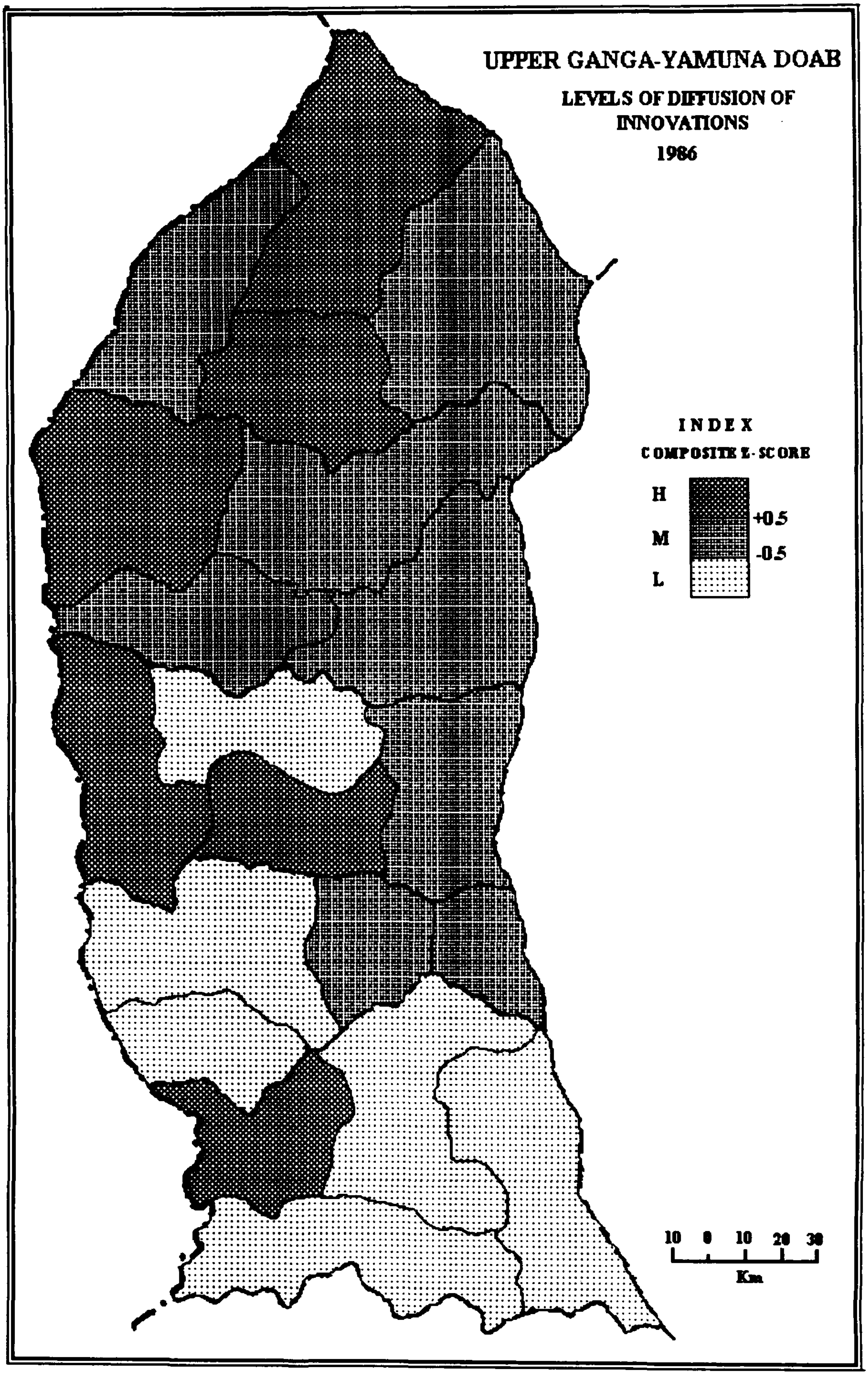
UPPER GANGA-YAMUNA DOAB
LEVELS OF DIFFUSION OF INNOVATIONS
1986
INDEX
COMPOSITE Z-SCORE
H
M
L
+0.5
-0.5
10 0 10 20 30
Km

Fig. 5.4E

Low Level of Diffusion of Innovations

The low level of diffusion of innovations comprises of four tehsils, namely Jansath, Dadri, Mavana and Anupshahr. The low level of diffusion of innovations is due to inadequate availability of irrigation, poor soils, small size of land holding, low literacy rates (40 percent) and density of population is 575 persons per square. km. (Figure 5.4 F).

From the above analysis, it may be concluded that the variations of level of diffusion of innovations are characterised by the variations in physico-cultural and socio-economic condition of the region, because it has direct bearing on the diffusion of agricultural innovations. The region, which has adopted high level of diffusion of innovations, is characterised by high irrigation, bigger size of land holding, high literacy, exposure to mass media, social awareness. It is suggested that medium and low level of diffusion region may be brought to the level of high diffusion of innovations provided the high level of irrigation, high literacy, exposure of mass media, availability of better marketing facilities, communication and transportation be made available to the respective region of the study area.

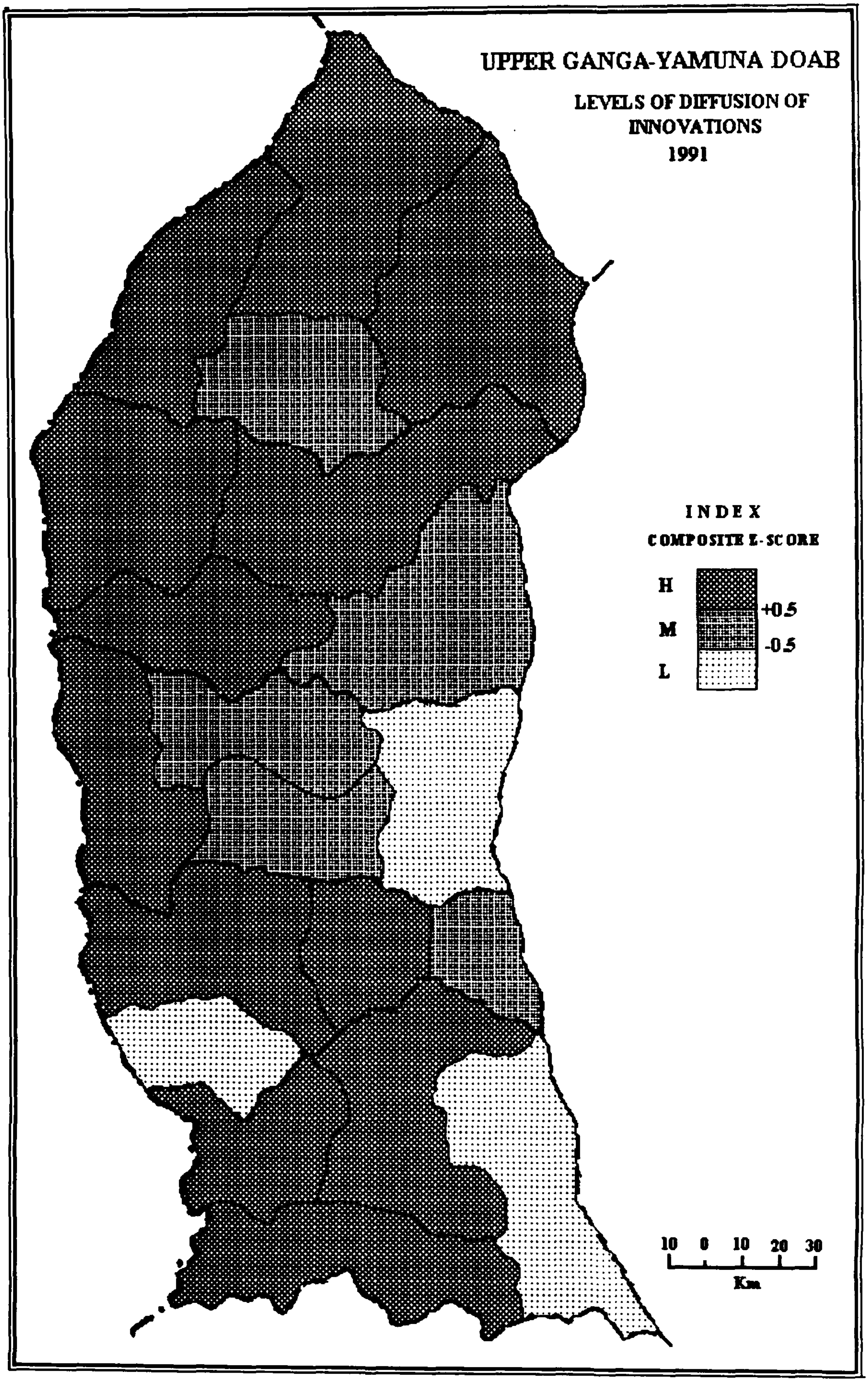
UPPER GANGA-YAMUNA DOAB
LEVELS OF DIFFUSION OF INNOVATIONS
1991
INDEX
COMPOSITE Z-SCORE
H
M
L
+0.5
-0.5
10 0 10 20 30
Km

Fig. 5.4F

CORRELATION BETWEEN AGRICULTURAL PRODUCTIVITY AND DIFFUSION OF AGRICULTURAL INNOVATIONS

The relationship between agricultural productivity and the rate of diffusion of innovations is depicted in the form of scatter diagram. The Figure 5.5 A reveals that the agricultural productivity ranges from - 3000 to 8000 Rs per hectare and the scattering of dots lies between these two limits. In relation to range of scattering, the rate of innovations varies from –2 to +2. Though the relationship is positive but it encompasses a wider width and this is also confirmed by the coefficient of correlation (r = 0.2011). In 18 degree of freedom at 0.05 and 0.01 level of significance the calculation value is greater than the table value at that particular level of significance, further confirms high level of significance between productivity Rs. per hectare and diffusion of innovations.

Figure 5.5 B reveals the agricultural productivity ranges from 3,000 to 9,000 Rs. per hectare and scattering of dotes lies generally between 4,000 to 9,000 except one dots. In relation to the ranges of scattering the rate of innovations varies from –2 to +2. The relationship is strongly positive and maximum concentration of dots around 5,000 to 9,000 Rs. per hectare clearly reveals the positive relationship. This is also confirmed from the coefficient of correlation (r = 0.5734). The 't test' at 0.05 degree of freedom further confirm the high level of significance between agricultural productivity Rs. per hectare and diffusion of innovations. This is due to the impact of green revolution.

The relationship between agricultural productivity Rs. per hectare and diffusion of innovations is shown in Figure 5.5 C in the form of scatter diagram. The diagram reveals that the productivity ranges in between 4,000 to 1,200 Rs. per hectare and scattering of

Correlation Between Agricultural Productivity Rs./Hect. and Diffusion of Innovation in Upper Ganga-Yamuna Doab

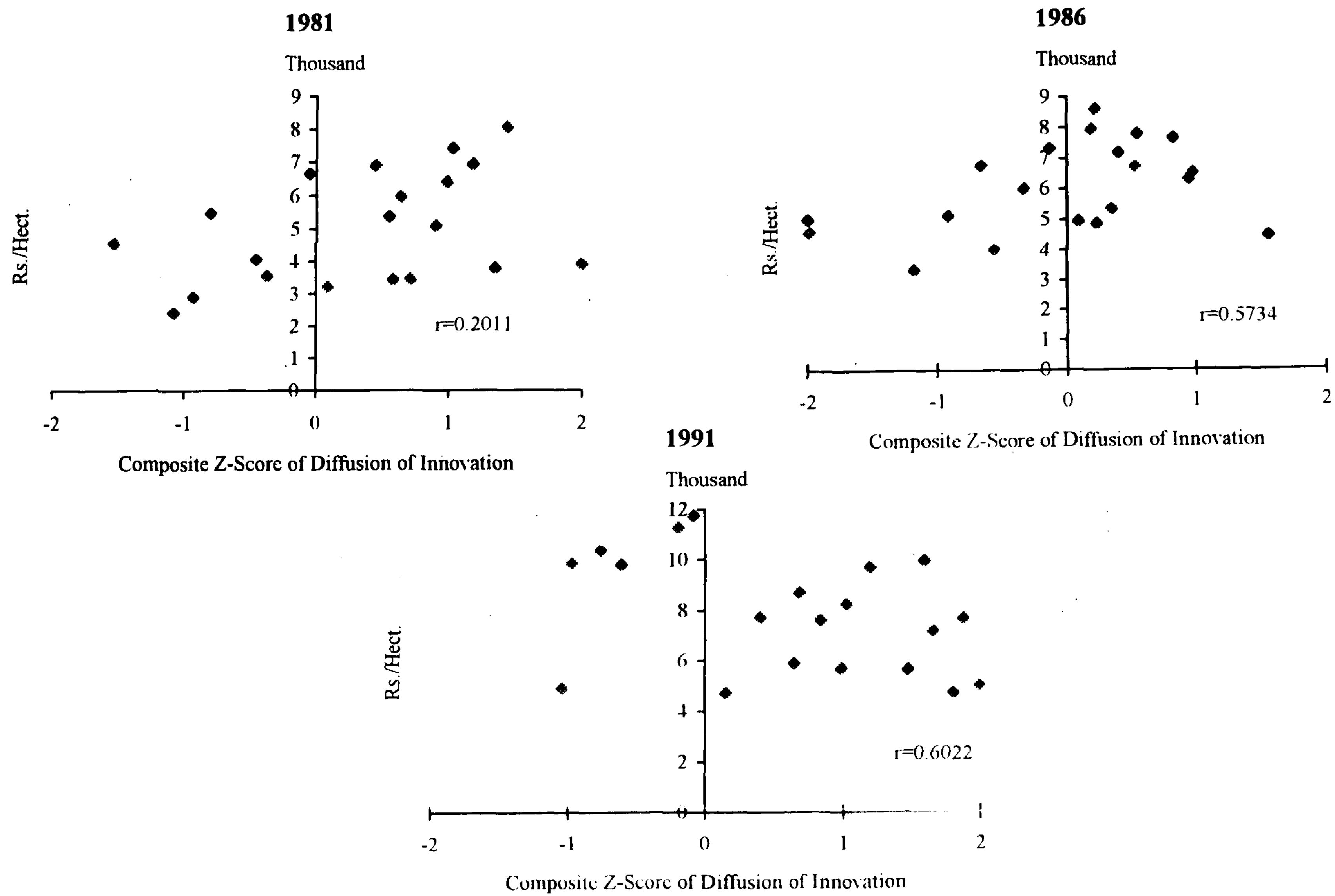

Fig. 5.5 A,B,C

dots lies between these two limits. The range of innovations varies from -2 to +2. The relationship is positive but it encompasses wider width and this is also confirmed by the coefficient of correlation (r = 0.6022). In 18 degree of freedom the 't test' at 0.05 to 0.01 level of significance the calculated value is greater than that of table value at that particular level, further confirms the high level of significance.

The foregoing analysis regarding the relationship between agricultural productivity Rs. per hectare and diffusion of innovations in Upper Ganga-Yamuna Doab at tehsil level based on three years' moving average at the breaking point of time 1981–1986–1991, clearly reveals the positive correlation though high rate of productivity and diffusion of innovations is observed in 1986 and followed by 1991 The reason behind the high rate of diffusion is the impact of green revolution and social awareness regarding the acceptance of innovations but in 1991 the rate is not as much as in 1986, because the farmers are not only paying their attention towards the production of food grains but also towards the cash crops which are more remunerative (Table 5.4).

15

Table 5.4

Correlation Between Agricultural Productivity and Diffusion of Innovations

S.No	Tehsils	Year 1981		Year 1986		Year 1991	
		X	Y	X	Y	X	Y
1	Saharanpur	3447	+0.71	7792	+0.55	7153	+1.66
2	Nakur	5361	+0.55	5370	+0.35	5883	+0.65
3	Roorkee	3781	+1.35	4945	+0.09	4709	+1.81
4	Deoband	5097	+0.90	6726	+0.53	4734	+0.15
5	Kairana	6892	+0.45	6298	+0.95	8688	+0.69
6	Muzaffarnagar	7417	+1.03	7324	-0.13	9673	+1.2
7	Budhana	6945	+1.18	8615	+0.22	8228	+1.03
8	Jansath	8050	+1.44	7193	+0.4	9829	-0.61
9	Baghpat	5476	-0.80	6506	+0.98	9932	+1.6
10	Sardhana	6423	+0.99	5039	-2	11283	-0.19
11	Mavana	6647	-0.05	7951	+0.19	10400	-0.76
12	Meerut	5963	+0.64	7655	+0.83	11765	-0.08
13	Ghaziabad	3427	+0.58	4037	-0.56	5632	+1.48
14	Hapur	4061	-0.45	4881	+0.23	7649	+1.88
15	Garmukteswar	3551	-0.37	6027	-0.33	7719	-0.4
16	Dadri	2418	-1.08	3354	-0.18	4935	-1.04
17	Sikandrabad	3215	+0.09	4475	+1.56	5685	+0.99
18	Bulandshahr	3918	+2	5151	-0.92	7606	+0.84
19	Anupshahr	4556	-1.53	6779	-0.66	9894	-0.97
20	Khurja	2886	-0.93	4627	-1.99	5021	+2

Note : X = Agriculture Production Rs/Hect.

Y = Composite Z-Score of Diffusion of Innovations.

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CHAPTER VI

IMPACT OF TECHNO-INSTITUTIONAL AND SOCIO-ECONOMIC FACTORS ON DIFFUSION OF INNOVATIONS

IMPACT OF TECHNO-INSTITUTIONAL AND SOCIO-ECONOMIC FACTORS ON DIFFUSION OF AGRICULTURAL INNOVATIONS

After the Green Revolution a wide range of farm innovations have been introduced in India, which has brought major changes in farming methods and practices in all parts of the country. The response of the farmers to innovations, however, does vary significantly as between different regions and even within a single region there are sharp differences as between different farms communities depending upon socio-economic conditions.

Besides the socio-economic condition of different farm communities a response of farmers to innovations also vary with respect to the location of their villages near or far away from the respective headquarters like blocks, tehsils and district, as well as their accessibility to the means of transportation and communications. The headquarters are considered as the important centre of diffusion of innovation. With this view an attempt has been made to examine the impact of techno-institutional and socio-economic factors on diffusion of agricultural innovations in Upper Ganga-Yamuna Doab.

The region having vast expanse of uniform space enjoying high fertility of soil, and density of population. The majority of people live in villages hence keeping the time and resources in view, it was not possible to conduct the survey of all the villages. Therefore, stratified purposive sampling technique has been adopted. The region have been divided into five homogenous stratas on the basis of relief, climate, drainage, soil, land use, cropping patterns in kharif and rabi seasons together with crop combinations.

From each strata different number of villages have been selected (Figure 6.1). The highest number of villages i.e., eight

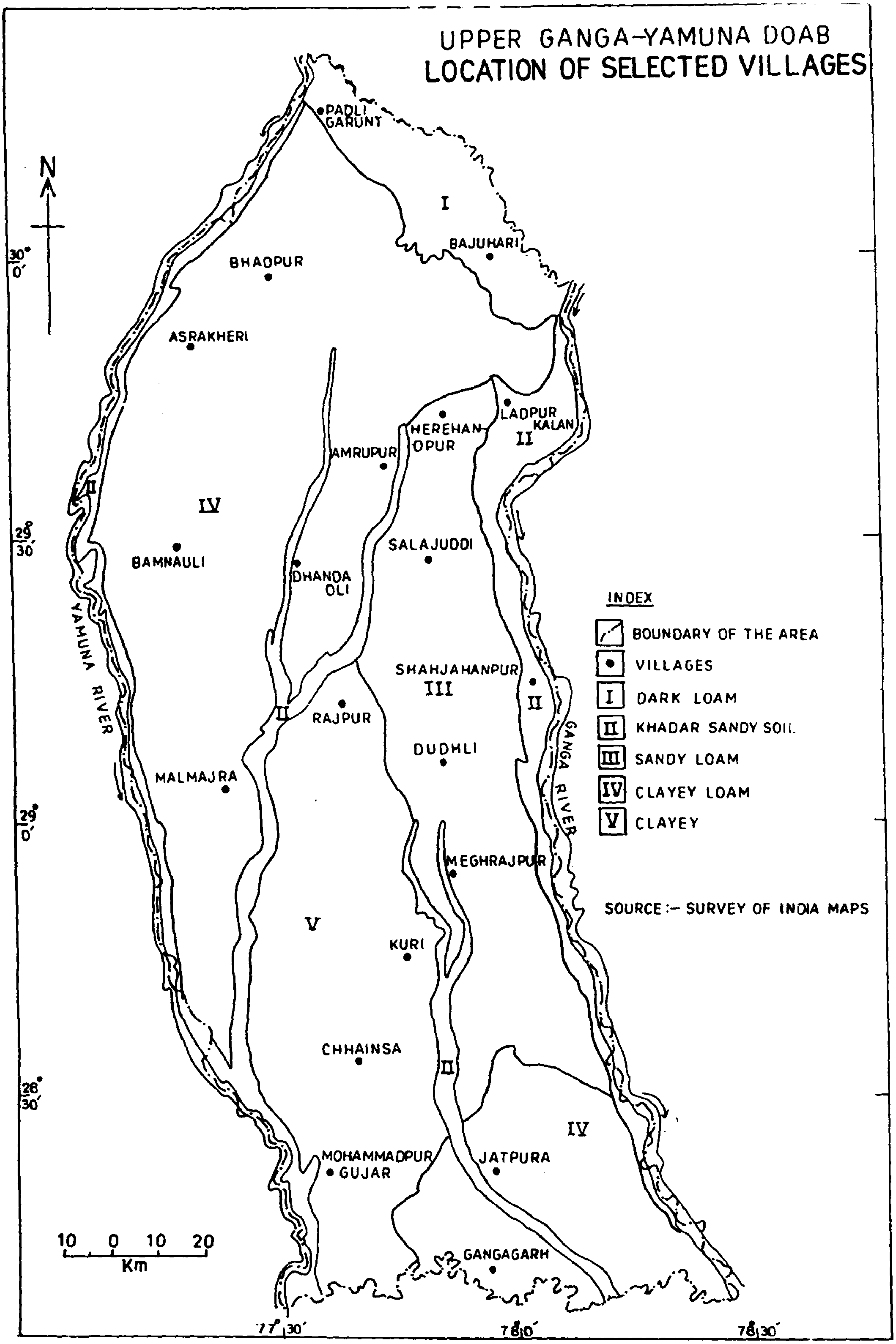
UPPER GANGA-YAMUNA DOAB
LOCATION OF SELECTED VILLAGES
N
PADLI GARUNT
I
BAJUHARI
BHAOPUR
ASRAKHERI
LADPUR KALAN
HEREHAN-OPUR
II
AMRUPUR
II
IV
BAMNAULI
SALAJUDDI
DHANDA OLI
YAMUNA RIVER
SHAHJAHANPUR
III
II
RAJPUR
II
DUDHLI
GANGA RIVER
MALMAJRA
MEGHRAJPUR
V
KURI
CHHAINSA
II
IV
MOHAMMADPUR GUJAR
JATPURA
GANGAGARH
10 0 10 20
Km
30° 0′
29° 30′
29° 0′
28° 30′
77° 30′
78° 0′
78° 30′
INDEX
BOUNDARY OF THE AREA
VILLAGES
I DARK LOAM
II KHADAR SANDY SOIL
III SANDY LOAM
IV CLAYEY LOAM
V CLAYEY
SOURCE :- SURVEY OF INDIA MAPS

Fig. 6.1

belongs to fourth strata and the lowest number of villages taken from first and second strata. However, the total number of 20 villages comprises of 3125 households. Only twenty-percent households have been taken into account for the present analysis. The villages within the strata have been selected according to their communication index which have been examined on the basis of its means of transport, their location with their respective district, tehsil and block headquarters, post office, police station, co-operative bank, rural bank, market, educational institution, village level workers residence and cinema hall.

Several agricultural innovations have been introduced in the study area during sixties, seventies, eighties and nineties. But only major and important innovations have been taken into consideration in the present study. There are institutional, technological and socio-economic factors, which comprises of 12 factors altogether such as size of land holding, tenurial status, irrigation, electric power and diesel, credit, subsidy, input, yield, fair prices, level of exposure to mass media, level of education and social position

The total number of households in the selected villages is 3125. Out of this 20 percent households (625) were selected for the present study on random basis. The fieldwork was done in 1996-97 in both the agricultural seasons. The articulate farmers, who were the functional heads of the family and are instrumental in decision making in agricultural matters, were personally interviewed in order to get primary data at the village and farmer level. Besides this district and tehsil level data were collected from their respective headquarters.

With the help of the scoring scheme the individual scores of all the respondents with respect to adoption of selected innovations were worked out. The standing score of each respondent was also calculated with respect to economic variables so as to group him or her in various categories. Finally in order to know the rate of adoption individual group of the entire variable, the average adoption is worked out. With the help of individual adoption score of the respondents of each group and the various hypotheses formulated regarding the impact of different factors on diffusion of agricultural innovation have been tested through average adoption index.

Size of Land Holding vs. Adoption of Agricultural Innovations

In an agricultural economy like ours, the value of land hardly needs any emphasis and in fact it is one of the most important indicator to measure ones socio-economic status. Several sociological and socio-anthropological studies have well established this fact Roy[1] (1968). The value of land in a region under study could be judged by the fact that even today the marriages within the caste are arranged on the basis of agricultural land which is likely to come in the share of bridegroom. However, with regard to adoption of agricultural innovations and size of holding are two contrasting views. According to one group of scholars there is positive and high correlationship between the size of holding and adoption of agricultural innovations (Mohammad[2], 1978, Desai[3], 1966). The arguments put forth in its support are: firstly, many innovations such as tractor, power, sprayer, power duster and harvester can be used economically only in contiguous and large strip of fields; secondly, the adoption of innovation as a matter of risk taking, because sometimes, a widely tried innovation like I.R.S. seed may result in substantial failure, if amount of rainfall is inadequate or plant protection measures are not timely taken; thirdly, many innovation require substantial amount of capital which is beyond the resources of small farmers; and finally, ownership of large holdings also influence the extent of adoption by way of making possible a high degree of educational status and assured irrigation facilities. On the contrary there is another group of scholars who, believe that there is a negative correlation between these two variables (Basu[4], 1978). The small farmers adopt agricultural practices earlier than the bigger ones, because the farmer due to low income and production, is highly motivated to increase his level of living by adopting new farm practices, whereas the latter does not feel the need so intensively to raise his overall output.

Besides this, he finds it difficult to concentrate his intensive efforts on an extensive area. The other view in this connection is that both variables are independent and there is hardly any relationship between the two. But the author feels that there is a positive correlationship between the two variables up to a certain size of holding (let us say up to 20 hectare) and beyond that the negative correlation begins.

With this view in mind the following hypothesis is formulated in order to test the relationship between the size of holdings and adoption of agricultural innovations.

The farmers of large size of holdings tend to adopt improved agricultural practices more than the farmers of other size of holdings.

For the assessment of size of holding, operational holdings have been taken into account for which data were obtained during fieldwork and were cross checked with the records of the village accountant. The operational size of holding varies from 0.2 hectare to 20 hectares but the average size of holding is 1.4 hects. On the basis of size of holding the sample farmers were classified into five groups as given below:

Group A	Large size farmers	> 10 hectares
Group B	Medium size farmers	> 10 – 4 hectares
Group C	Semi – medium size farmers	> 4 – 2 hectares
Group D	Small size farmers	> 2 – 1 hectares
Group E	Marginal farmers	< 1 hectare

On the basis of total individual scores of the respondent, the average adoption index of each group of farmers is worked out. Table 6.1 shows that there are only 27 farmers (4.32 percent) whose size of holding is more than 10 hectares but their average adoption index is highest (4.8561). The marginal farmers (302) accounting 48.32 percent of the sample farmers have lowest average adoption index (0.5382).

Table 6.1

Size of Holding vs. Average Adoption Index

S. No.	Group	No. of Farmers	Average Adoption Index
1.	Group A	27	4.8561
2.	Group B	58	4.3293
3.	Group C	93	2.1987
4.	Group D	145	0.9796
5.	Group E	302	0.5382

The semi-medium and medium farmers who together account 24.16 percent of the sample farmers have an average adoption index of 2.1987 and 4.3293 respectively. The small farmers constituting 23.20 percent of sample farmers have an average adoption index of 0.9796. Table 6.1 and Figure 6.2 clearly show that there is a positive correlationship between the size of holding and average adoption index viz., with the increase in size of holding, adoption index also increases.

Tenurial Status vs. Adoption of Agricultural Innovations

Tenurial status is another important economic indicator of the status of agricultural communities. It is very vague and complex in India generally the farmers who own the land in their names enjoy higher socio-economic status as compared to those who are either owners or share-croppers. The popular feeling is that the owner farmers having assured agricultural land are more innovative and

Size of Holding vs. Average Adoption Index

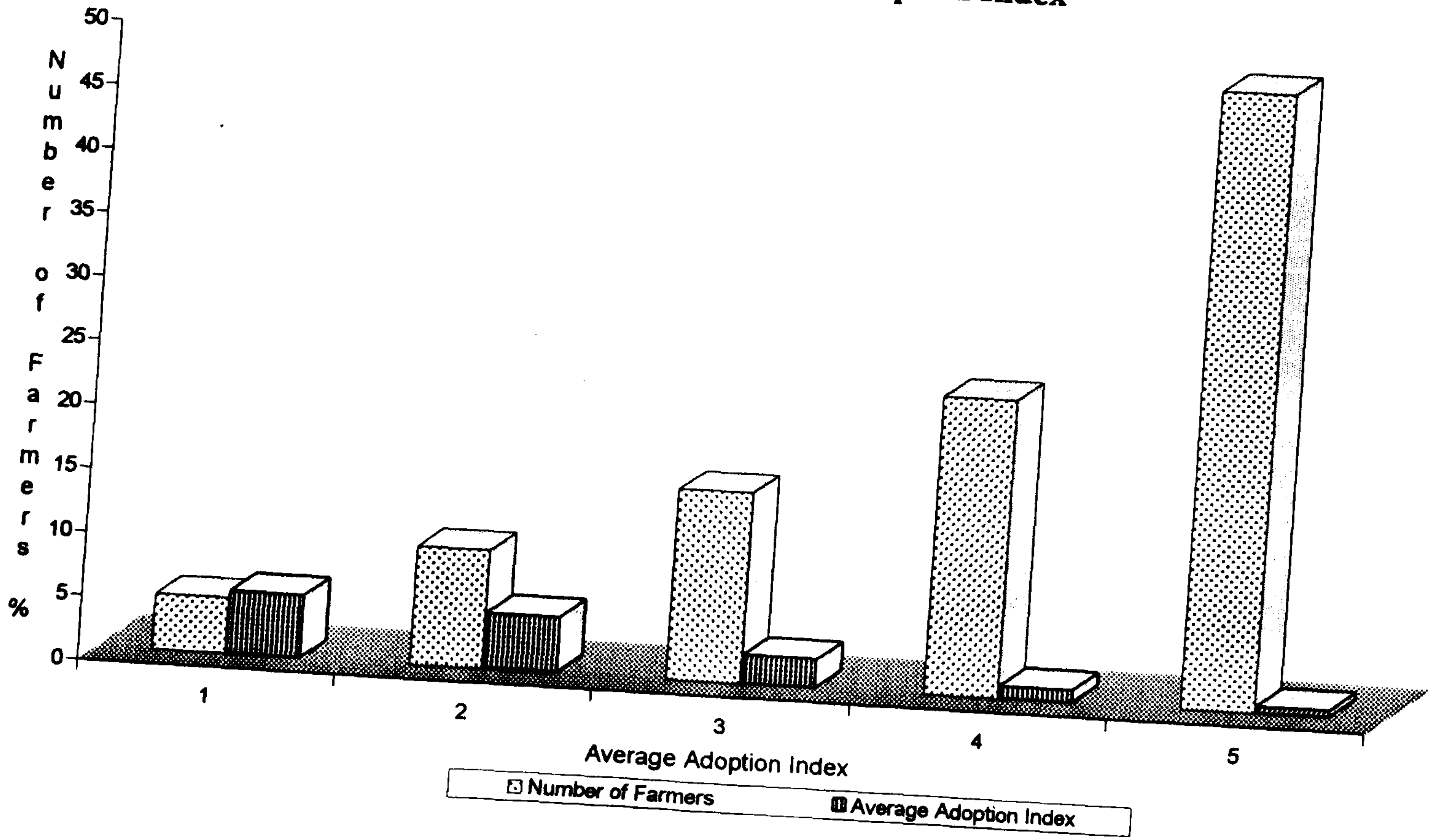

Figure 6.2

adoptive of new farm practices. But like size of holding there are three contrasting views with regard to tenurial status and adoption of agricultural innovations viz. positive correlation (Savale[5], 1966; Bill and Zusman[6], 1976; Das Gupta[7], 1963), negative correlationship and no correlation (Chaudhary and Maharaja[8] 1968). The first view seems to be more correct as the farmers are owners of land; secondly, they need not to pay anyone if crop fails. Where as the tenant or share-croppers have to pay the contractual amount in any case; thirdly, they being assured of agricultural land can adopt permanent innovations of long duration; and finally, the owner farmers are economically better of which results in higher literacy index and more progressiveness. However, in order to test the relationship between these two variables the following hypothesis is put forth,

The rate of adoption among owner farmers is high as compared to owner-share-cropper or share-croppers.

Table 6.2

Tenurial Status vs. Average Adoption Index

S.No	Group	No. of Farmers	Average Adoption Index
1	Owner	209	3.9072
2	Owner-share-cropper	314	3.1392
3	Owner – Cropper	102	1.3465

It is quite obvious from Table 6.2 and Figure 6.3 that owner farmers who account roughly one-third of the total respondent have highest average adoption index (3.9072), where as the share-croppers have an average index of 1.3465. There are only 102(16.32 percent) exclusively share-croppers. The owner- share-croppers who account roughly half of the total respondents have also high adoption index (3.1392) and, therefore, the analysis proves the first

Tenurial Status vs. Adoption of Agricultural Innovation

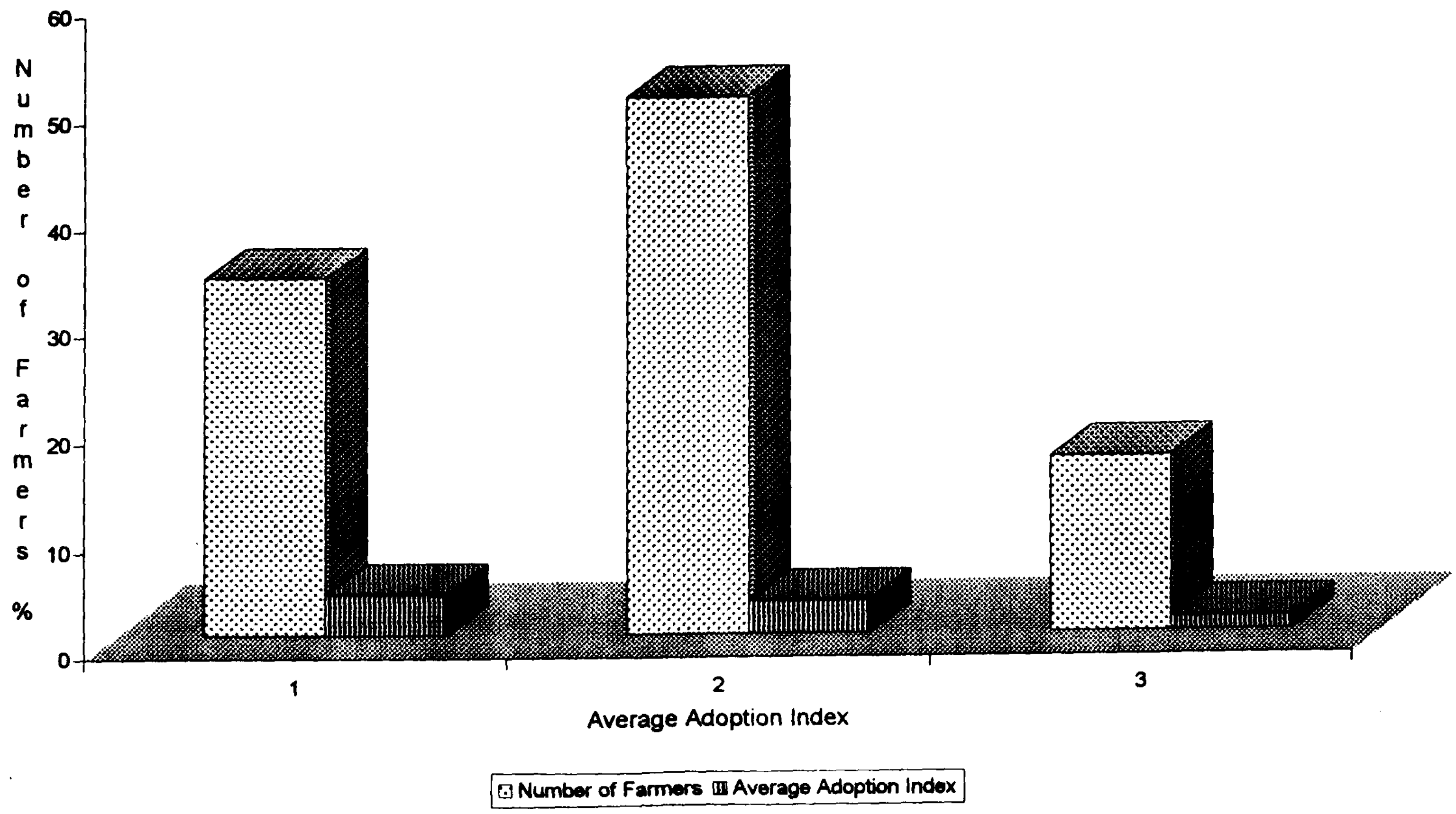

Figure 6.3

proposition i.e., the tenurial status and adoption of agricultural innovation are positively related.

Irrigation vs. Adoption of Agricultural Innovations

Irrigation is indeed the life-breathe of agriculture. Its importance in the development of agriculture in general and monsoonal countries in particular hardly needs any emphasis. Very often it plays a decisive role in selection of crops to be sown, cropping pattern, intensity of cropping, crop combination, extent of yield and time of sowing the crops. A number of analytical studies have proved that India can increase its agricultural production to a large extent, if adequate and assured irrigation affects to a great extent. The adoption of certain agricultural innovations like chemical fertilizers and manures, new varieties of seed, plant protection chemicals, because these innovations require assured and high irrigation water.

Almost all the studies conducted to find out the impact of irrigation facilities on adoption of agricultural innovation have concluded the positive correlationship between the two variables viz., farmers with adequate and assured irrigation facilities adopt improved agricultural practices much earlier as compared to others (Mohammad[9], 1976; Rangaswamy[10], 1972; Bowden[11], 1965). However, in the present study attempt has been made to test this relationship further. Therefore, the following hypothesis has been formulated in this connection:

The farmers having adequate and assured irrigation facilities are more adoptive of agricultural innovations as compared to others.

For the assessment of the individual standing of the farmers with respect to irrigation facilities, a scoring scheme is evolved. For each crop the farmer having adequate, average, poor and very poor irrigation facilities is given the score of 4,3,2, and 1 respectively. His total score is worked out by adding his scores in respect of all the crops grown by him and this figure is divided by number of crops cultivated by him in order to get his average scores. The average adoption score varies from 0 to 4. Finally on the basis of their average scores the farmers are classified into following four groups:

Group A	Adequate irrigation facilities	> 3.0 scores
Group B	Average irrigation facilities	30.20 scores
Group C	Poor irrigation facilities	21.10 scores
Group D	Very poor irrigation facilities	< 1.0 score

Table 6.3

Irrigation vs. Average Adoption Index

S.No	Group	No. of Farmers	Average Adoption Index
1	Adequate	65	4.6872
2	Average	187	2.9235
3	Poor	256	1.6482
4	Very Poor	117	0.8763

Table 6.3 and Figure 6.4 show that only 10.4 percent of the total farmers have adequate irrigation facilities and their average adoption index is highest (4.6872). The farmers having average irrigation facilities account 29.92 percent of the sample and their average adoption index is 2.9235. The farmers having poor and very poor irrigation facilities account about 59.68 percent of the respondents and their average adoption indices are poor i.e., 1.6482 and 0.8763 respectively. The above analysis is very much in conformity with the earlier studies and it proves that there is positive correlation between these two variables.

Electric Power and Diesel vs. Adoption of Agricultural Innovations

The electric power and diesel (here after written as power) play very significant role in the development of agriculture especially in the mechanization and rationalisation of farm

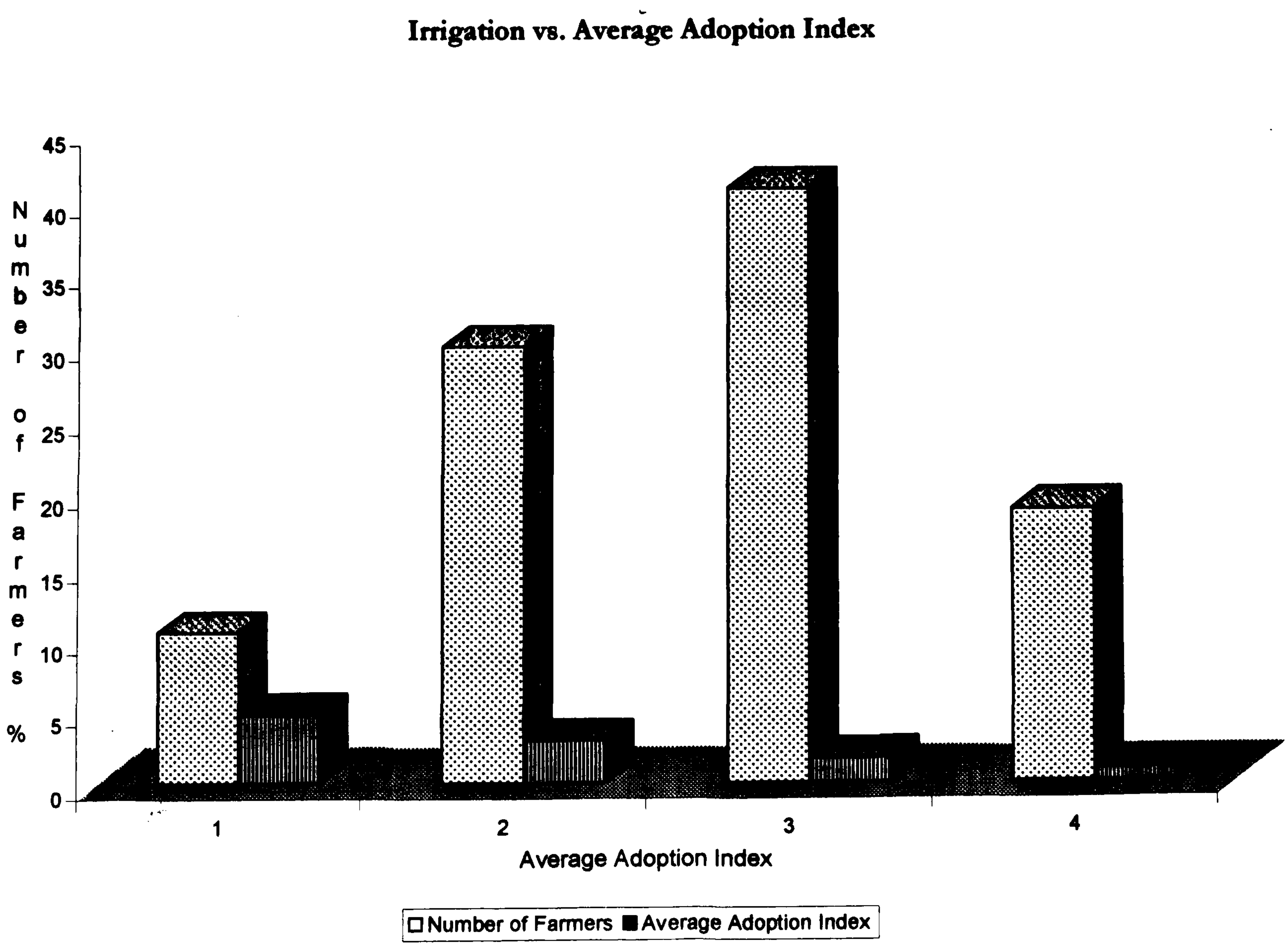
Irrigation vs. Average Adoption Index
Number of Farmers %
45
40
35
30
25
20
15
10
5
0
1
2
3
4
Average Adoption Index
Number of Farmers
Average Adoption Index

Figure 6.4

operations (Barnea, 1953-54). Power is used in various agricultural operations such as lifting of water from tube wells, tanks and rivers, ploughing, spraying of plant protection chemical, harvesting and crushing. The electric pumps, oil engine and pump sets are widely used for lifting water for irrigation purposes. Hence, it is expected that when power is available in abundance for irrigation and non-irrigation purposes, the farmers be in a better position to adopt agricultural innovations. Therefore, in the present study the hypothesis is that

Adequate and timely availability of power tends to promote speedy adoption of agricultural innovations among farmers.

On the basis of mode of consumption of power, farmers are classified into four groups. Group A consists of those farmers who use power for both irrigation and other agricultural operations; group B includes the farmers using power for irrigation only; group C consists of farmers using power for agricultural operations and group D is the group of farmers who do not use power at all.

Table 6.4

Power vs. Average Adoption Index

S.No	Group	No. of Farmers	Average Adoption Index
1	Group A	58	3.4975
2	Group B	204	1.8961
3	Group C	143	3.6573
4	Group D	220	1.0387

The average adoption index of each group is calculated with the help of individual adoption score. From the Table 6.4 and Figure 6.5, it is obvious that there are 220 farmers (35.2 percent) who do not use power and consequently their average adoption index is lowest. The farmers of group C have highest average adoption index (3.6573) and they account roughly 22.88 percent of the sample farmers. The farmers of group A and group B together account 41.92 percent of the sample farmers and their average adoption indices are 3.4975 and 1.8961 respectively.

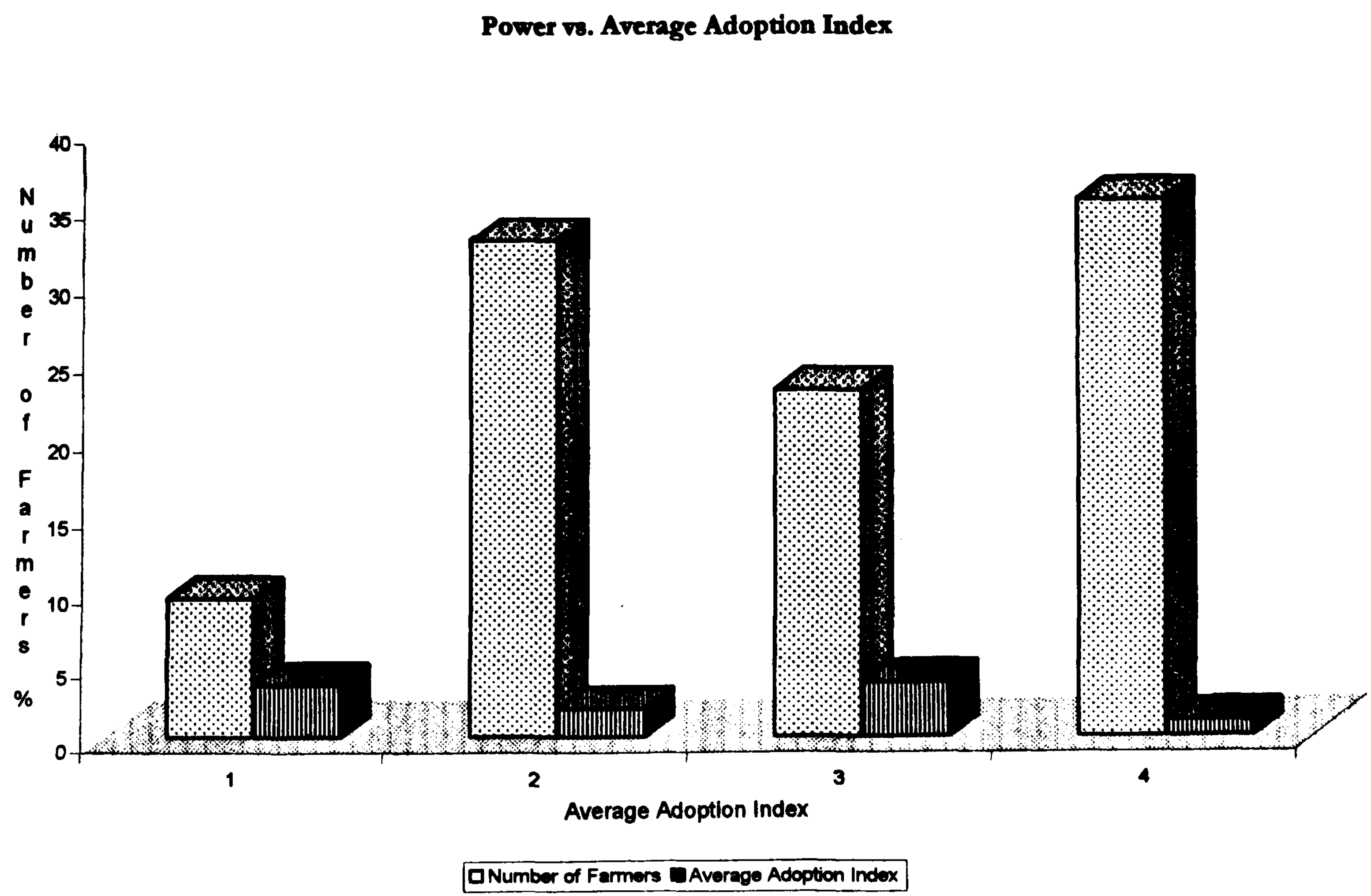
Power vs. Average Adoption Index
40
35
30
25
20
15
10
5
0
Number of Farmers %
1
2
3
4
Average Adoption Index
Number of Farmers
Average Adoption Index

Figure 6.5

Credit vs. Adoption of Agricultural Innovations

Finance is one of the most important economic determinant and lifeblood of any enterprise, and agriculture is no exception to it. For the agricultural development in general and adoption of agricultural innovation in particular, substantial amount of capital is required. But the Indian farmer is too poor to afford it properly. He has to borrow money at a very high rate of compound interest from various sources like middlemen, moneylender, and commission agents for his day to day life and occasional ceremonies. They exploit him to the maximum extent. The rèsult is that the farmers hardly get rid of the debt of these agencies. It is rightly remarked that Indian farmers, by and large, born, live and die in debt. Hence, question hardly arises to borrow money from these sources for adoption of agricultural innovations. However, the government and various co-operative societies are gradually trying to help them out by providing credit facilities at lower interest rate. Several studies have highlighted the fact that if adequate and timely credit at lower interest rate is available to the farmers, they would adopt agricultural innovations more quickly. Keeping above fact in view it is hypothesised.

Availability of adequate and timely credit facilities promote quick adoption of agricultural innovations.

There are 390 farmers (62.4 percent) who had applied for credit and remaining 37.6 percent did not do so. Out of this, a small percentage do not need credit at all but the large percentage of farmers did not apply for credit to a number of reasons viz., fear of high compound interest, wrong higher entries inability to return in time resulting to social insult and harassment and doubt of getting it sanctioned within time. Hence, only 390 farmers have been included in the study.

In order to assess the standing of farmers in case of credit facilities a scoring scheme in which 4, 3, 2 and 1 scores were given to adequate-timely, inadequate-timely, adequate-untimely and inadequate-untimely availability of credit respectively. Zero score was given for non-availability of credit. According to the scoring scheme the total score of the individual farmers was worked out and was divided by number of items for which he had applied for credit in cash or kind. This gives his average score, which varies from 0 to 4. According to average score the farmers were classified into five groups as given below.

Group A	Got credit adequate-timely	> 3.0 Scores
Group B	Got credit inadequate-timely	3.0 – 2.0 Scores
Group C	Got credit adequate-untimely	2.1-1.0 Scores
Group D	Got credit inadequate-untimely	< 1.0 Scores
Group E	Did not get credit	0 Score

Table 6.5 and Figure 6.6 show that there is a close relationship between the adequate and timely availability of credit and adoption of agricultural innovations.

Table 6.5

Credit vs. Average Adoption Index

S.No	Group	No. of Farmers	Average Adoption Index
1	Category A	39	3.9127
2	Category B	110	3.4932
3	Category C	53	2.3553
4	Category D	81	1.6102
5	Category E	107	0.8120

The farmers who got adequate and timely credit have highest average adoption index (3.9127) while the adoption index of those farmers is lowest who were in need of credit and applied for that but did not get it. There are 107 such respondents. The farmers of group B account for the highest percentage (28.2) and their average

Credit vs. Average Adoption Index

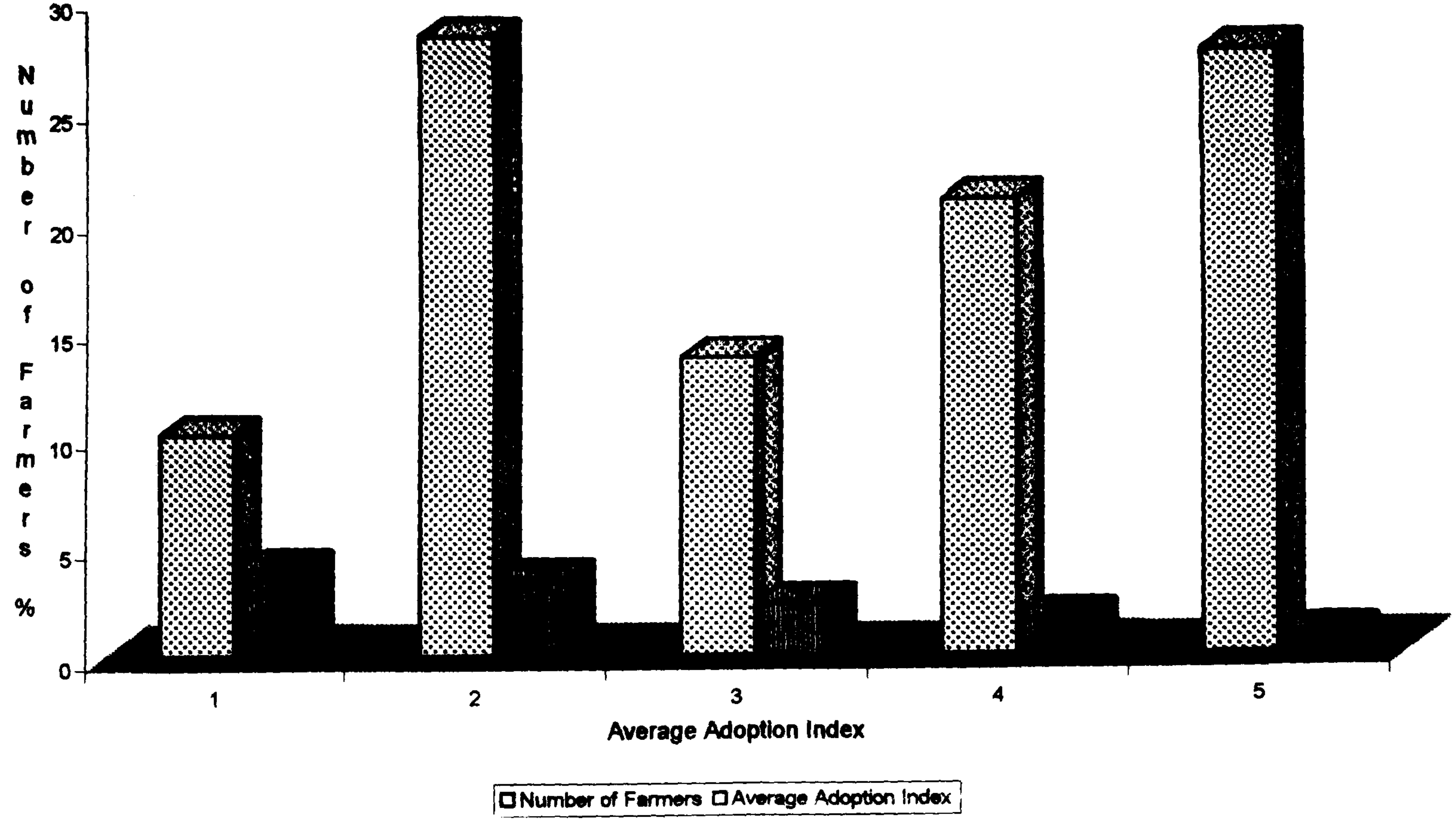

Figure 6.6

adoption index is reasonable. The farmers of category C and D who together account for 34.35 percent has average adoption indices 2.3553 and 1.6102 respectively. The above analysis proves that adequate and timely availability of credit facilities for needed potential adopters promotes adoption of agricultural innovations.

Subsidy vs. Adoption of Agricultural Innovations

The provision of incentives in some form or the other immensely contributes to increase production and efficiency. Therefore, the necessity for application of incentive has been universally recognised in a culture where every one is working for someone else and the fruits of one's labour do not reside directly in accomplishment but occur in some more indirect form such as wages. The use of incentives as a spur to increase production rests upon a thoroughly sound psychological foundations, where incentives fail, the difficulty may be treated to a failure to understand their nature so their misuses, or to a false conception of what can be expected from them. It is evident from available data and various studies that the incentive schemes especially those involving financial benefits works well with poor in poor income groups.

The general experience is that if incentives are given in proper time and in adequate measure, they contribute substantially to enhance the practice adoption. Therefore, the hypothesis put forth in this connection is as follows

Availability of incentives in the form of subsidies tends to promote speedy adoption of improved agricultural practices.

In order to test hypothesis only those sample farmers (369) have been taken who applied for various kinds of subsidies. The average score of each farmer is worked out by dividing his total score with by number of items he had applied for subsidy.

Finally the respondents were classified into following groups on the basis of their response and feeling towards subsidies

Group A	Very good
Group B	Good
Group C	Satisfactory
Group D	Poor

Table 6.6

Subsidy vs. Average Adoption Index

S.No	Group	No. of Farmers	Average Adoption Index
1	Group A	48	3.6398
2	Group B	57	2.5952
3	Group C	102	1.8786
4	Group D	162	0.9893

It is evident from Table 6.6 and Figure 6.7 that the number of respondent is in ascending order while average adoption index in descending order. This is a clear proof of the fact that the farmers who got very good amount of subsidies in time have highest adoption index whereas reverse in the case for last group.

About 13 percent of respondents of the study fall in group A and 43.9 percent in group D. The respondents of group B who accounts for 15.4 percent have reasonable adoption index of 2.5952. The average adoption index of the respondents of group C accounts for 27.6 percent is also poor.

Input vs. Adoption of Agricultural Innovations

The process of adoption of new farm practices is a complex one and it involves in many stages such as awareness interest, evaluation, trial and finally adoption. It requires knowledge, skill and will among farmers in order to make use of improved methods of agriculture. In addition to this, adequate and timely availability of various agricultural inputs like chemical fertilizers, improved varieties of seeds, plant protection, chemicals and credit facilities,

Subsidy vs. Average Adoption Index

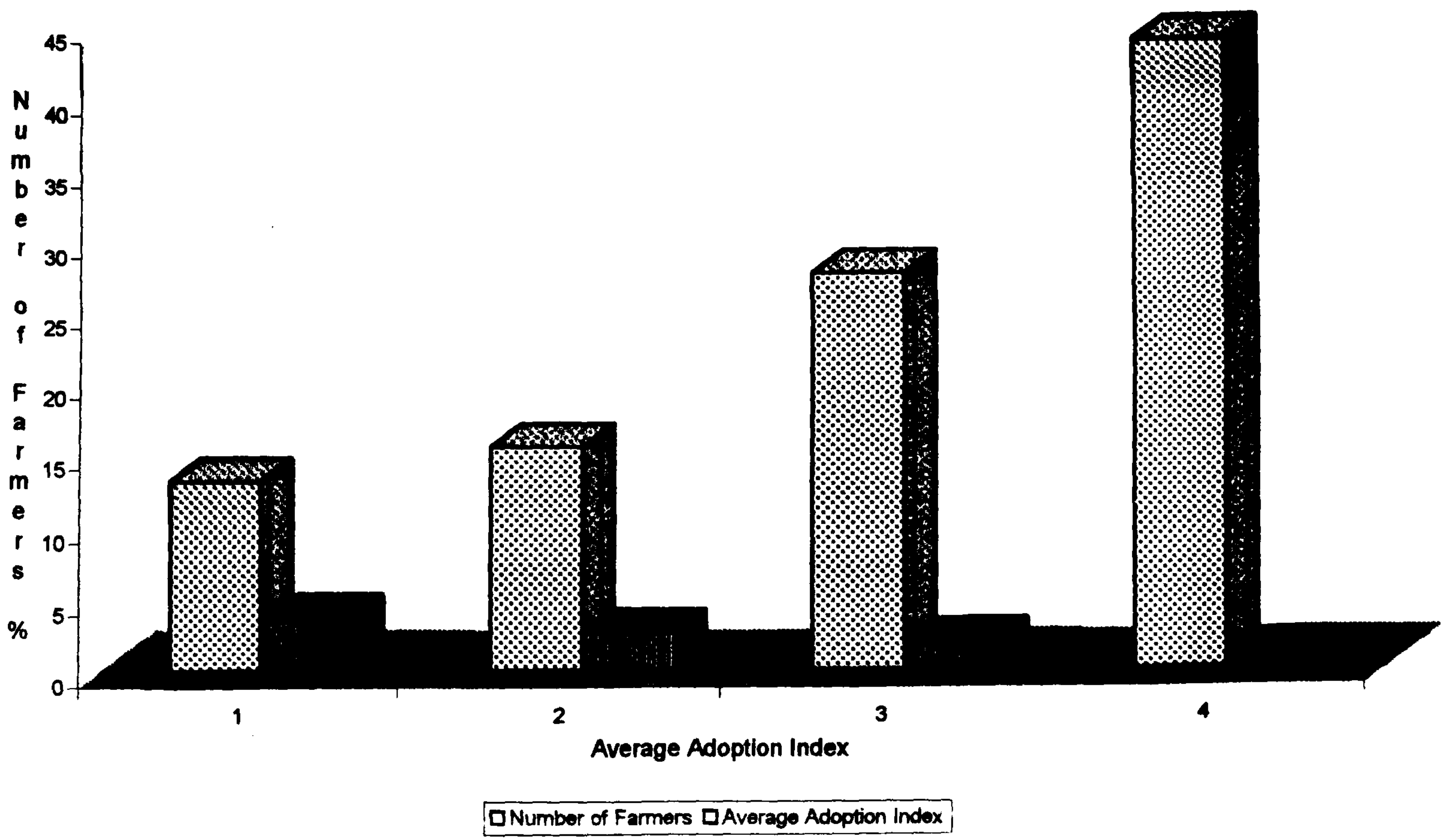

Figure 6.7

also play major role in diffusion of agricultural innovations. In several studies it has been observed that non-availability of adequate agricultural inputs is one of the bottlenecks in bringing about technological change in agriculture. Very often in a adequate and untimely supply of inputs results in cooling down the enthusiasm of farmers in adopting innovations. Hence, agricultural inputs should be made available to the farmers as soon as he makes up his mind to adopt them. Hence, it is interesting to study the impact of this aspect on innovativeness of farmers with reference to some selected agricultural innovations. The hypothesis formulated in this connection is as follows

Timely and adequate availability of inputs promotes adoption of agricultural innovations.

In order to assess the standing of farmers in case of availability of inputs a scoring scheme is evolved in which adequate-timely, inadequate-timely, adequate-untimely and inadequate-untimely, availability of inputs are given 3.5, 2 5, 2.0 and 1.0 scores respectively. Zero score was given for non-availability of inputs. On the basis of this scoring scheme the farmers' total score is worked out and is divided by the number of item he had applied for in order to get his average score. The average score of farmers varies from 0 to 3. Finally on the basis of the average score, the farmers were classified into 5 groups as given below:

Group A	Adequate-timely	> 2.0 Scores
Group B	Inadequate -timely	2.0 – 1.5 Scores
Group C	Adequate - untimely	1.4 – 1.0 Scores
Group D	Inadequate - untimely	0.9 – 0.5 Score
Group E	Did not get at all	< 0.5 Score

The average adoption index is worked out on the basis of the adoption score of the individuals. Table 6.7 and Figure 6.8 show that the adoption index of group A is much higher (4.5694) than the

Input vs. Average Adoption Index

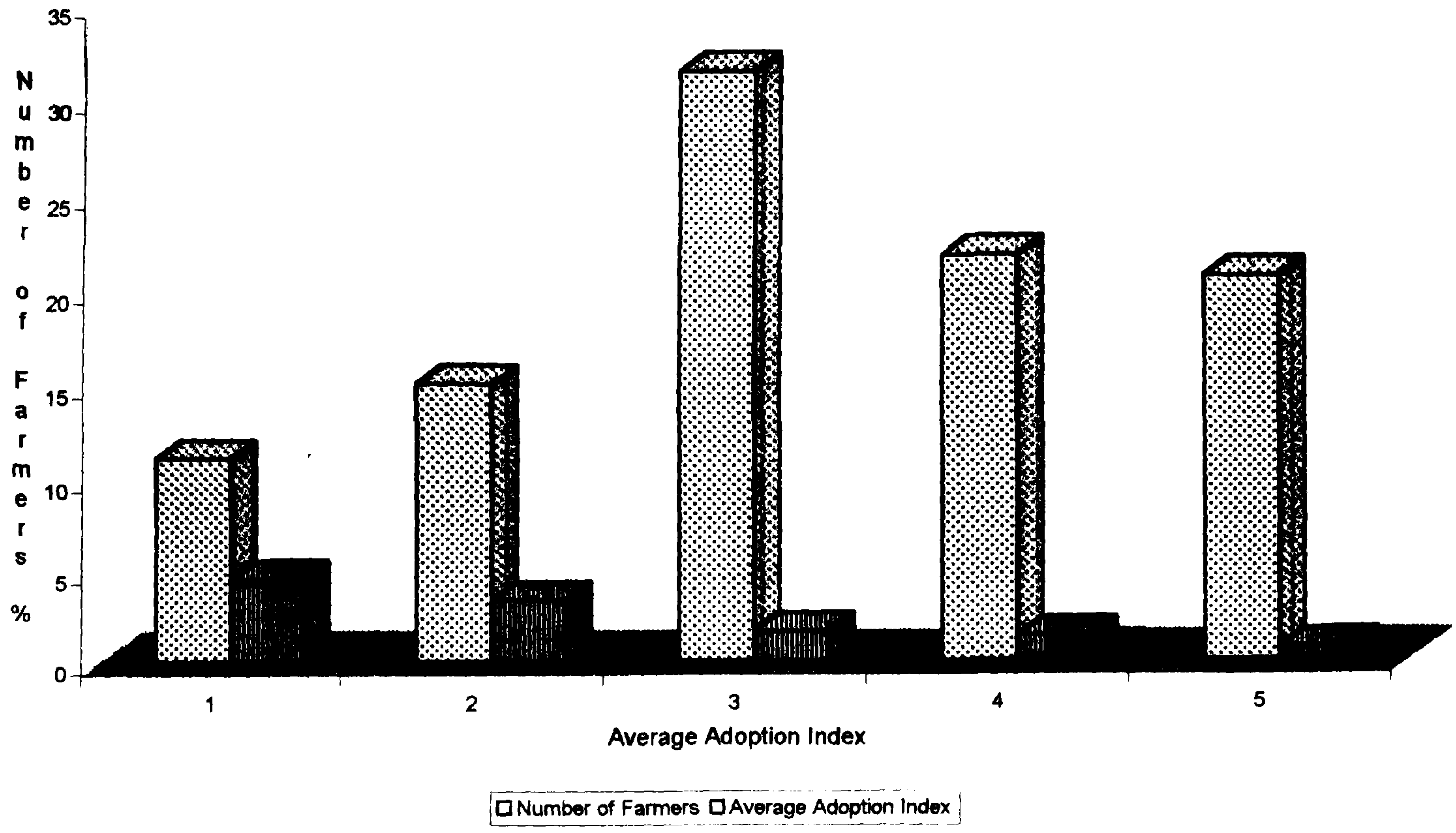

Figure 6.8

rest of the groups, but there are only 69 farmers (11.04 percent) who have got inputs adequate and timely to a large extent. About one- fifth of the farmers did not get the required inputs and, perhaps, as result their adoption index is lowest (0.7358). The adoption index of farmers of group D who account more than one-fifth of the total farmers is also low (1.3821).

Table 6.7

Input vs. Average Adoption Index

S.No	Group	No. of Farmers	Average Adoption Index
1	Category A	69	4.5694
2	Category B	94	3.3987
3	Category C	197	1.6857
4	Category D	136	1.3821
5	Category E	129	0.7358

The farmers of category C constitute slightly less than one-third of total respondents is 1.6857 while the adoption score of the remaining 15 percent respondents falling in group B is 3 3987 which is almost satisfactory. This analysis clearly establishes the fact that adequate and timely availability of inputs affects the adoption of agricultural innovations to a considerable extent.

Yield vs. Adoption of Agricultural Innovations

Yield is another economic variable, which affects the adoption of agricultural innovations. It is altogether different variable as it is a practice centred characteristics whereas other variables are all predominantly farm centred. However, the agricultural innovation to be adopted by farmer must prove superior to those it has to replace. The superiority is to be looked into from the economic as well other points of view. However, as the ultimate target of a farmer in adopting a farm practice is to get higher return, agricultural innovations which give quick, better and more return diffuse must earlier than those which are inferior in yield. This view has been propounded by Fliegel and Kilvin[11] (1968) in his studies. Hence, the hypothesis in this connection is as follows,

The rate of adoption of an innovation is positively related to its ultimate returns.

In order to assess the standing of farmers with respect to yield position, a scoring scheme is evolved in which a comparison could be made between per hectare yield obtained by applying purely traditional method and that obtained by using modern techniques. With the help of this, the standing score of each farmer is worked out and they are divided into the following groups:

Group A	Respondents getting greater yield	> 1.5 scores
Group B	Respondents getting equal yield	1.5 – 0.5 scores
Group C	Respondents getting lesser yield	< 0.5 score

Table 6.8 and Figure 6.9 show that about 58.14 percent of the sample respondents (485) got good and more yield and their average adoption index is high 3.9672. There are 104 respondents (21.4 percent) whose average adoption index is 1.4376, where as average adoption index of remaining 20 percent respondents is 2.6243. This analysis clearly proves the fact that the respondents who have got greater yield are more adoptive as compares to others,

Table 6.8

Yield vs. Average Adoption Index

S.No	Group	No. of Farmers	Average Adoption Index
1	Group A	282	3.9672
2	Group B	99	2.6243
3	Group C	104	1.4376

Yield vs. Average Adoption Index

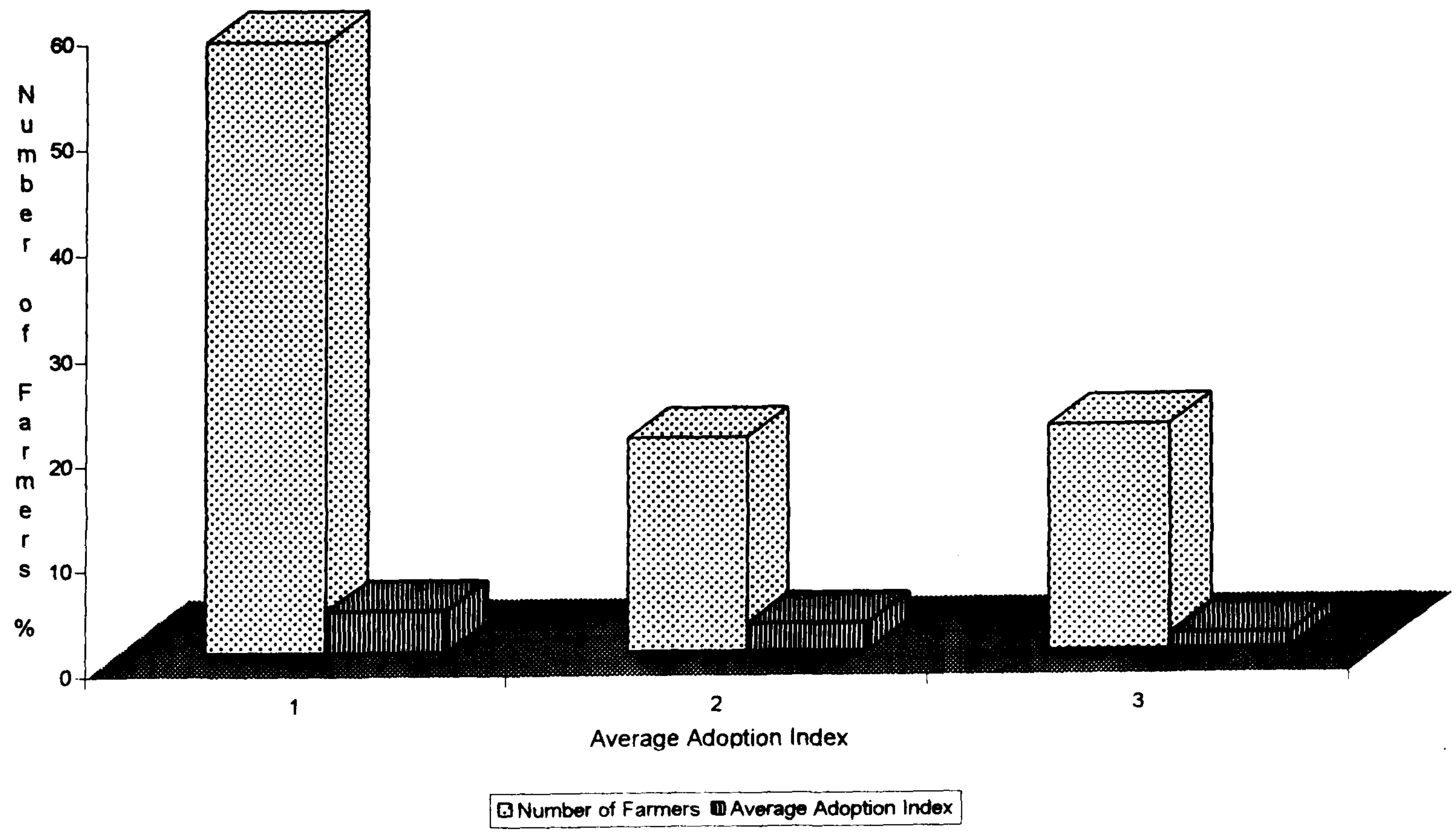

Figure 6.9

Fair Prices vs. Adoption of Agricultural Innovations

The availability of fare prices for the agricultural produce is another important economic indicator, which stimulates the farmers to adopt agricultural innovations. It is but natural that if a farmer is sure of getting a reasonable price for his produce, he would feel encouraged and enthusiastic to increase it by adopting more and more agricultural innovations. But reverse would be the case if he does not get reasonable price for his farm products. Infact the down ward pressure on price, especially when transport is deficient and storage is inadequate, may infact be so reverse as they have a distinctive effect on producers. Premature discouragement may lead to a slowing down in good production or even rejection of a new technology. According to Wharton, unless adequate attention is given to developing of incentives, the spread of new technology infact, be cut shortly before any take off has occurred (Wharton[12], 1969). Keeping these facts in view the following hypothesis is framed

Availability of incentives in the form of assured fair prices for agricultural produce tends to promote speedy adoption of agricultural innovations.

For the assessment of the standing of the farmers with respect to availability of fair prices, a scoring scheme is introduced for all the farmers who sold their farm produce at fair prices or otherwise. There are 538 such respondents. Their adoption score is worked out by dividing their total score with number of produce taken into consideration. On the basis of this, respondents were classified into three groups viz., group A consist of those who got good prices, group B for satisfactory prices; and group C unsatisfactory prices. The average adoption index of each group is calculated with the help of the individual score of respondents. Then the pattern of adoption of different group of farmers was studied.

Table 6.9 and Figure 6.10 show that the largest percentage of (538) respondent (58.17 percent) are satisfied with the price they have got for their agricultural produce and their average adoption index is also high. There are 343 respondents who have got good prices whose average adoption index is highest (3.6425). Only 9.8 percent of the respondents were not satisfied with the prices they have got and their average adoption index is low. The above analysis proves that the availability of fair prices for agricultural product does promote the speedy adoption of agricultural innovations.

Table 6.9

Fair Prices vs. Average Adoption Index

S.No.	Group	No. of Farmers	Average Adoption Index
1	Good	172	3.6425
2	Satisfactory	313	3.1743
3	Unsatisfactory	53	2.4987

Level of Exposure to Mass Media and Innovativeness

Farmer in the study of selected villages are, exposed to variety of mass media, such as television, radio/transistor, newspaper, cinema and so on. However, not all farmers were exposed to each of these media nor for the degree of exposure the same. In this section the degree of exposure to various mass media and innovativeness has been examined of the selected household in the study area.

In spite of several limitations, mass media plays an effective role in diffusion of agricultural innovations. It has generally been observed that level of exposure to mass media is positively correlated with the agricultural innovations. For the assessment of level of exposure of mass media of individual respondents, communications six form of mass media such as television,

Fair Prices vs. Average Adoption Index

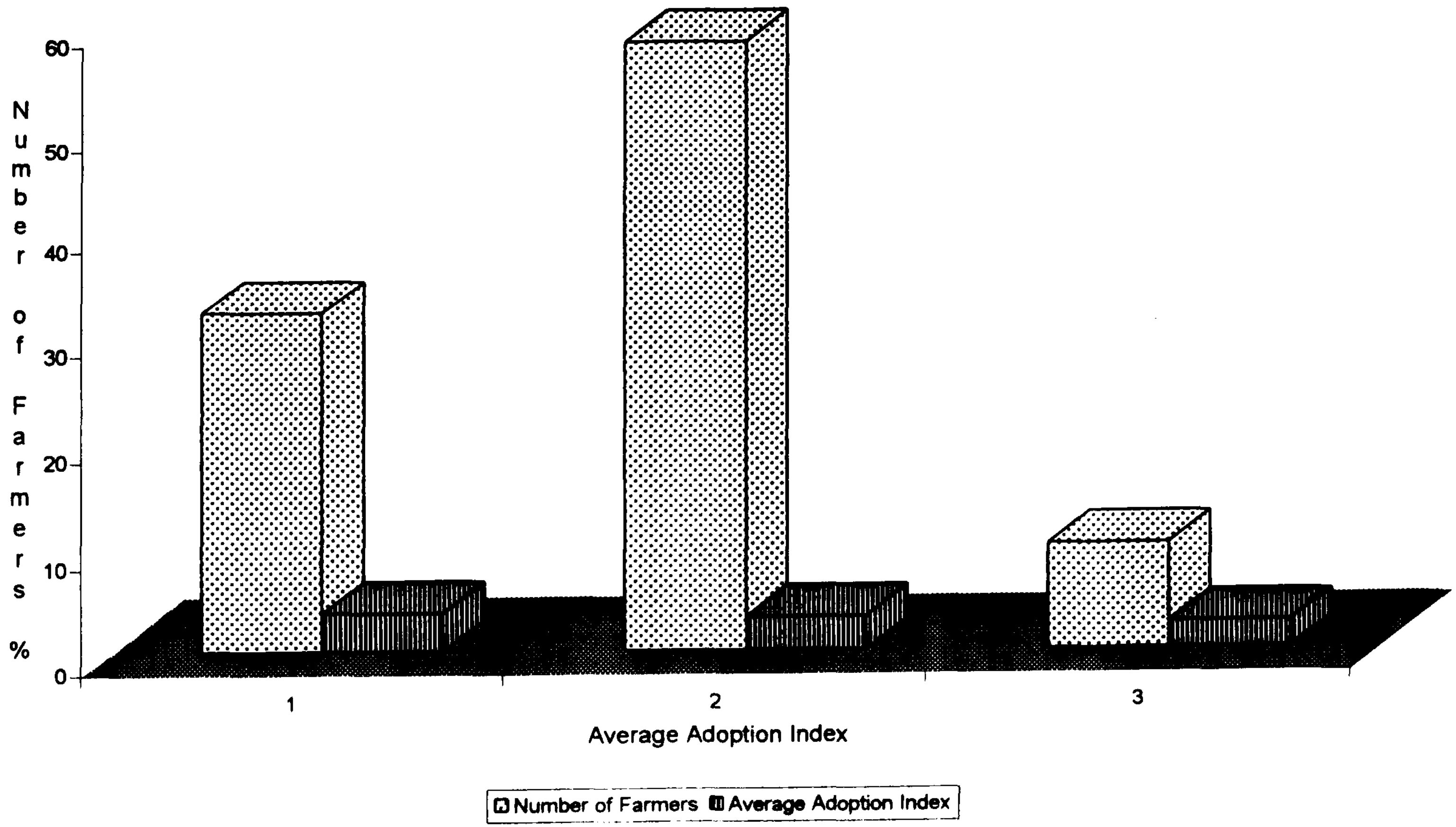

Figure 6.10

radio/transistor, cinema, newspaper, magazine and agricultural fair, and exhibitions has been taken. On the basis of the individual response, the total score of each respondent has been worked out with the help of a scoring method and they have been classified in 5 categories. On the basis of total individual scores of the respondents, the average adoption index of each group of farmer is worked out.

Table 6.10

Exposure to Mass Media vs. Average Adoption Index

S.No	Category	Score range	No. of Farmers	%age of the Farmers
1.	A- Very highly exposed	>8.50	26	4.16%
2.	B- Highly exposed	6.0 – 8.50	101	16.16%
3.	C- Moderately exposed	3.51 – 6.00	135	21.6%
4.	D- Less exposed	1.50 – 3.50	169	27.04%
5.	E- Least exposed	< 1.50	194	31.04

Table 6.10 and Figure 6.11 substantiates the belief of positive relationship between exposure to mass media and level of adoptions of innovation. The respondents of least exposed category have an average innovative adoptions index. The largest number of respondent is in the least exposed to mass media and their adoptions index of innovativeness is less than 1-50 score range. Only 4.16 percent of respondent (26) are very highly exposed to mass media with the average adoptions index is more than 8.50. The above analysis proves the hypothesis of positive relationship between level of exposure to mass media and adoptions diffusion of innovation. The basic reason for such an association is that the highly exposed respondents also belong to high caste with high socio-economic status and high literacy index. They have large size

Exposure to Mass Media vs. Average Adoption Index

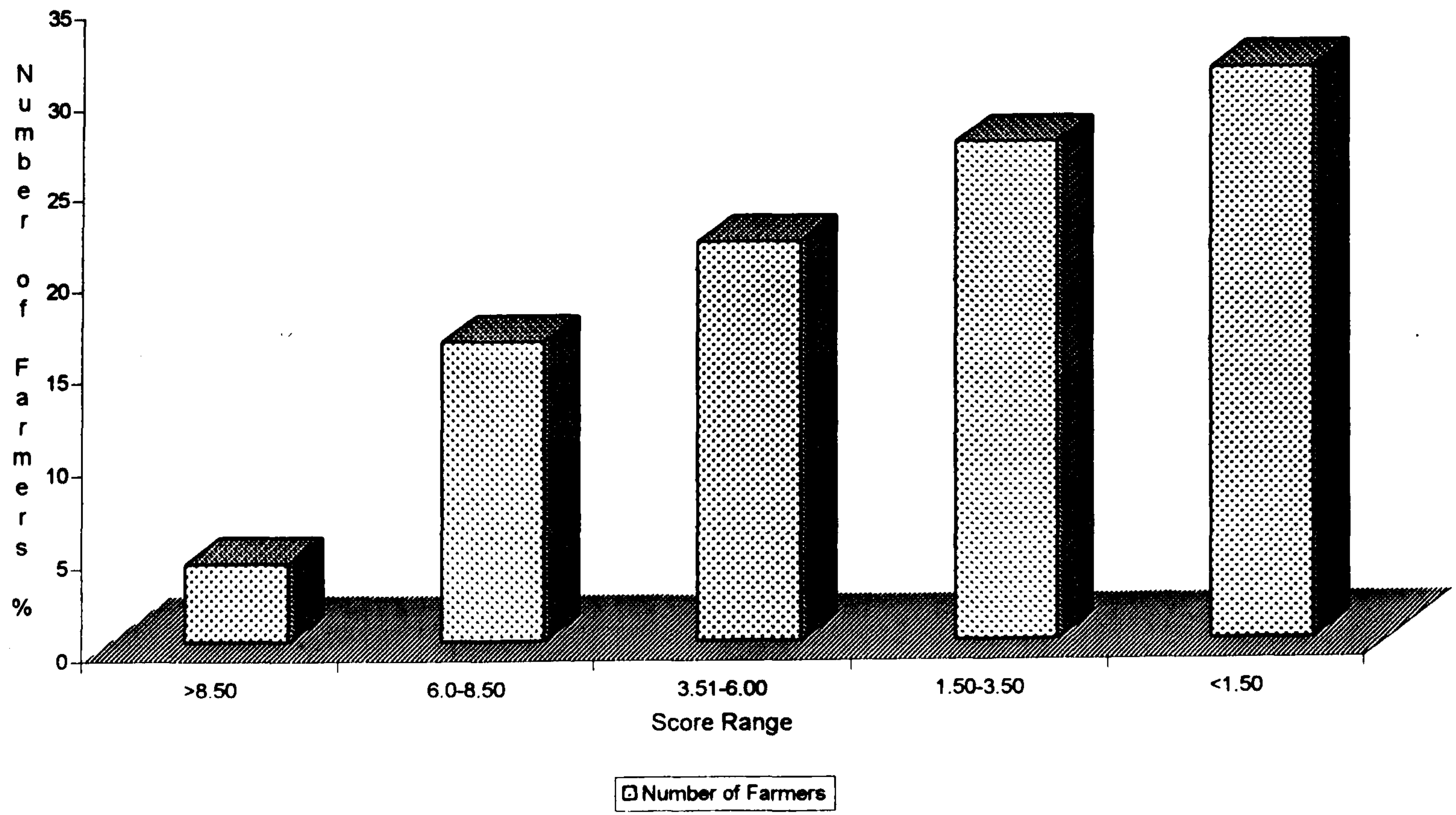

Figure 6.11

of holding with better agricultural infrastructure. All these factors are very helpful to the adoption of agricultural innovations, which subsequently increases agricultural productivity.

Level of Education vs. Agricultural Innovations

The role of education in the process of development of a region is quite obvious. It is one of the chief instruments through which society socialises its members and brings desirable changes in the social life of the people. Education is, in fact, the aggregate of all the process by means of which a person develops abilities, attitudes, and other forms of behaviour of positive value in the society in which he lives. It is a social process by which people are subjected to the influence of selected and controlled environment so that they may attain social competence and optimum individual development. And as such, it may be said that education influences the course of behaviour of both society and its individuals.

Table 6.11

Education Level vs. Average Adoptions Index of Innovativeness

S.No	Category	Score range	No. of Farmers	%age of the Farmers
1.	A- Very highly educated	> 4.50	16	2.56%
2.	B- Highly educated	3.51 - 4.50	34	5.44%
3.	C- Moderately educated	2.51 - 350	51	8.16%
4.	D- Less educated	below - 2.50	318	50.88%
5.	E- Illiterate	0.00	206	32.95%

Agricultural productivity is, by and large, influenced by the adoption of agricultural innovations. Since adoption behaviour of farmer is a learning process involving knowledge, attitude and skill regarding agricultural innovations, it cannot be exception to it. Several studies conducted in India and abroad (Sorokin[13], 1928;

Bose[14], 1961, Bose[15] 1962; Rahudkar[16], 1966) regarding technological change and diffusion of agricultural innovations, have proved to close positive relationship between the rate of adoption and literacy index. The educated farmers not only adopt agricultural innovations quickly but also in a better and more scientific way. Even in the traditional method of agriculture, he brings refinement and improvements, and eventually gets higher agricultural return.

The Table 6.11 and Figure 6.12 reveal level of education vs. adoption of innovativeness of 625 respondents. The highly educated respondent and very high educated respondent account 8 percent of the total respondent have very high adoption of innovative index. Where as more than 50 percent of the respondent have very low adoption index that is below 2.50. It proves the hypothesis that high literacy index has high adoptions index of innovativeness. It further clarify that there is positive correlation between level of education and adoptions of innovations. The reasons for positive correlation between educational status and adoptions of agricultural innovations are quite obvious. The educated farmers are well informed about agricultural innovations, more mobile, more liberal, and more receptive to agricultural innovations, and are capable of working out precisely the benefits and loss in agriculture by adopting innovations in it. Thus the above analysis shows the positive relationship between level of education and adoptions of agricultural innovations.

Social Position vs. Adoption of Agricultural Innovations

India is basically a social country where the religious and social norms, values, traditions and customs play important role in all walks of life. The social status of the people is, by and large, ascertained by his caste, occupation, educational level, standard of living, family income, administrative position, political involvement, level of involvement in various socio-religious and political activities. It has been generally observed that the

Education Level vs. Average Adoption Index of Innovativeness

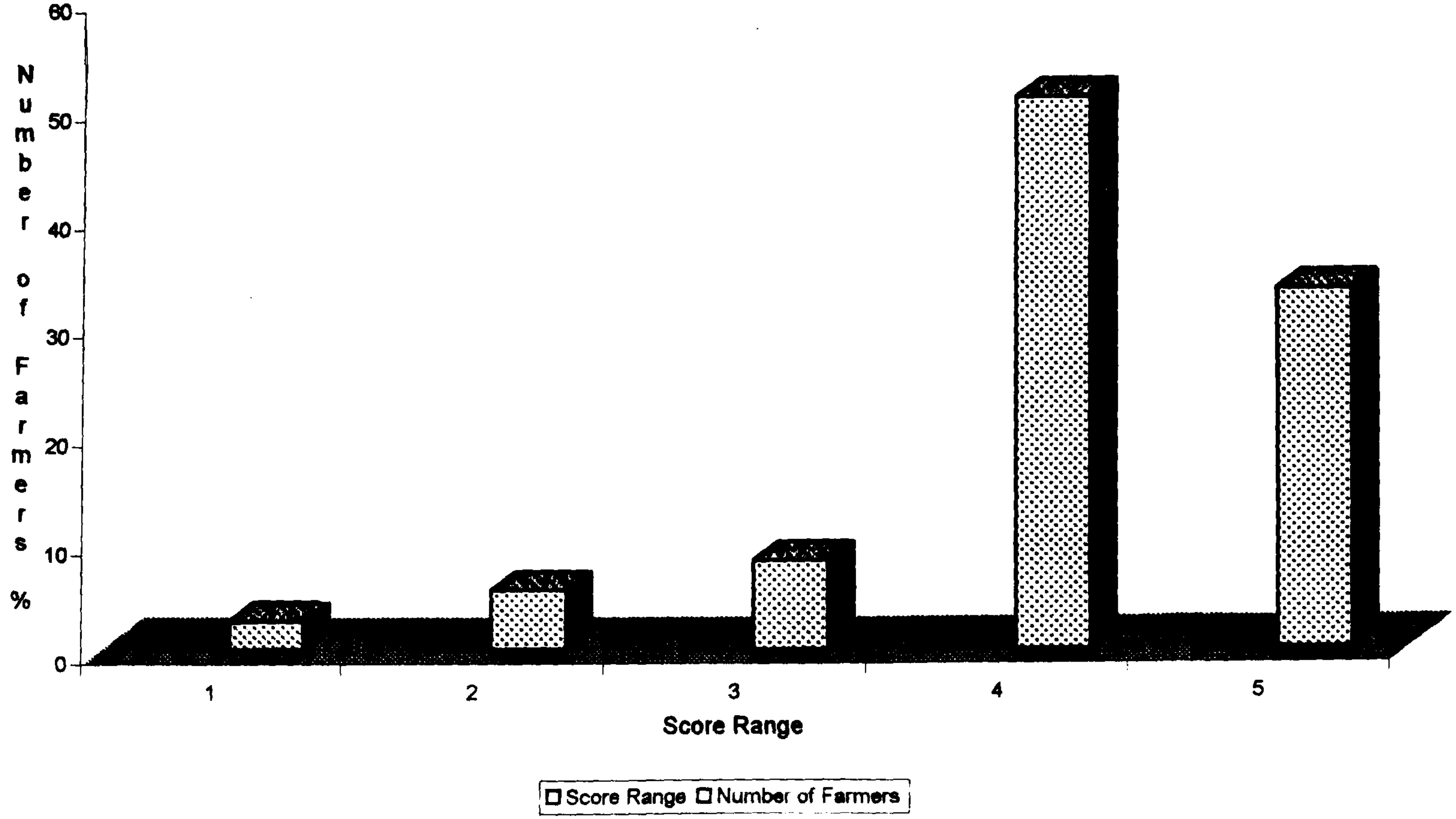

Figure 6.12

respondents of high social status are more liberal, open minded and receptive to agricultural innovations. Therefore, in the present study it has been hypothesised that there is a positive correlationship between the social status of the respondents and adoptions of agricultural innovations. Hence, the social status of all the respondents have been ascertained on the basis of the above indicators. Since the questions for ascertaining social status, included in the questionnaire, were of varied nature, and the answers given by the respondents were even more complex and heterogeneous, it was difficult to compare the respondents with one another. Therefore, a judicious scoring scheme was evolved, and all the respondents were given scores as per their response to questions. The score of individual respondents were added up, and they were arranged in ascending order. Finally, the respondents were classified into social status categories.

Table 6.12

Social Position vs. Adoption of Average Adoption Index Innovativeness

S. No.	Category	No. of Farmers	Percentage of Farmers	Score range
1	A- Very high	25	4.00%	> 5.50
2	B- High	167	26.72%	3.50 - 5.50
3	C- Medium	292	46.72%	2.50 - 1.00
4	D- Low	122	19.52%	1.0 - 0.50
5	E- Very low	19	3.04%	below 0.50

The Table 6.12 shows the average adoptions index of diffusion of agricultural innovativeness and various categories of social status in Upper Ganga-Yamuna Doab. It is obvious from the table the adoption of agricultural innovations among the respondents is quite uneven, according to the social status group. Table 6.12 and Figure 6.13 further show that there is a positive

Social Position vs. Average Adoption Index of Innovativeness

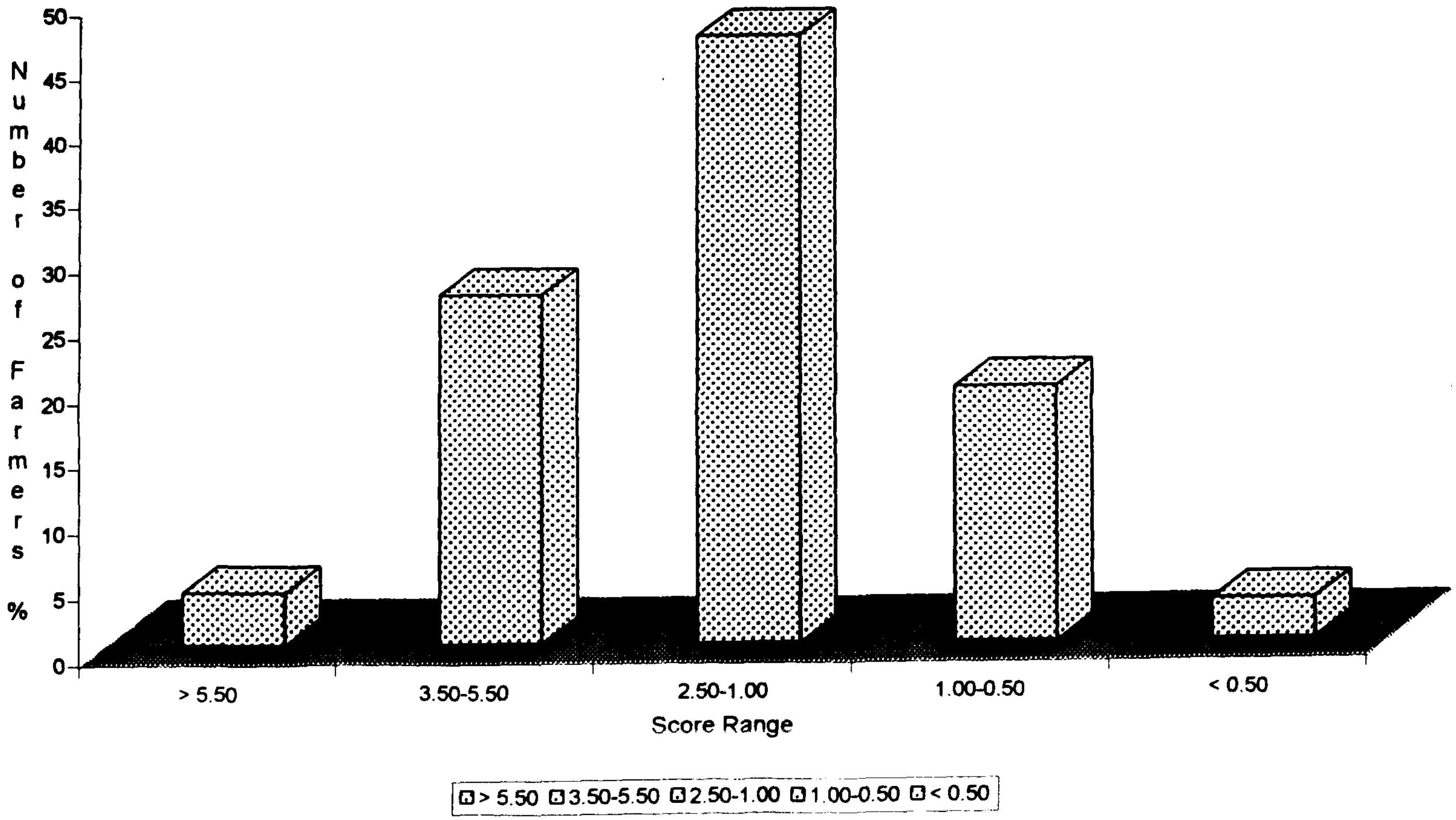

Figure 6.13

correlation between the social status of the respondents and their average adoption index of agricultural innovations. The analysis of the table further reveals that under very high social status group has the highest adoption index of agricultural innovations, but it constitute only 4 percent of the total respondents. This average adoption index is slightly higher than the high social status groups. They are generally Rajput, Brahiman; Jat and some Muslims respondents with large size of holding. Their over all socio-cultural conditions are similar to the respondents belonging to high social status category. About 27 percent respondents have high social status with adoption index ranging between 3.50 to 5.50. In this group by and large, the respondent of high caste are found. They are more educated and play major role in the socio-cultural affairs of the village. They are active members of various social, religious and political organisations. By virtue of being associated with various organisations, they come in contact with various government and quasi-government officials who come to the village for implementing various governmental programmes and policies for agricultural development. By virtue of being active and versatile members of the villages they are more receptive involved and respective to agricultural innovations, which results in higher agricultural productivity.

About 47 percent of cultivating respondents have medium social status. These respondents are found in the northwestern and southeastern and some places of central part of Upper Ganga-Yamuna Doab. Generally the medium social status comprises of Kurmi, Jat, Ahir, Shaikh and some Rajputs are predominant caste. About 22.55 percent of the respondents belong to low and very low social status group and out of them only 3.04 percent belongs to very low social status group. They are mostly scheduled caste and backward caste with a very low literacy index. Majority of them are illiterate and few of them are less educated. Hence, the level of reception of agricultural innovations is very low.

This analysis proves that the social status of respondents, which is the reflection of overall socio-economic and cultural conditions, is very much positively associated with adoption of agricultural innovations.

After foregoing discussion regarding the impact of techno-institutional and socio-economic factors on diffusion of agricultural innovations in the study area. It may be concluded that present study is too brief to make any generalization either at global or at national level, but predictions could be made fairly at high degree of certainty in this connection for all the geographical region with similar physico-cultural and socio-economic conditions. It is clear from this study that techno-institutional and socio-economic factors have played significant role in the process of diffusion of agricultural innovations. All the 12 factors considered in the present study have proved statistically significant and all have positive correlationship with diffusion of agricultural innovations. In the light of the above conclusions the following suggestions are made with regard to the impact of techno-institutional and socio-economic factors on diffusion of agricultural innovations in the study area.

The Upper Ganga-Yamuna Doab is covered under the settlement scheme of consolidation of land, and in most of the sample villages this programme is almost over. But the size of land is still, by and large, is very small. The size of plots can be judged by the fact that about 63.63 percent of the holdings are less than one hectare. It is due to several reasons; firstly, the consolidation programme is not properly and rationally chalked out. There are several flaws in it. It is not properly implemented as well and the farmers are given more than one plots in the same type of land. The farmers are harassed and they have to pay heavy prices for it.

Secondly, farmers themselves prefer to have at least one plot in each soil type due to subsistence economy. Thirdly, the social tradition of Indian farmers to distribute the land among their sons and grandsons has further reduced the size of the plots. Therefore, it is recommended that rational programme of consolidation should be implemented and legal restrictions should be imposed on fragmentation of holding. Besides this, attempt should also be made to consolidate the small holdings through co-operative and joint farming.

With regard to tenurial status it has been proved that owner farmers have highest adoption index as compared to share-croppers. There are several reasons for this. The uncertainty in the duration of tenancy psychological feelings of detachment, small size of operational holdings and haphazard planning of cultivations are some of the important reasons. It is, therefore, suggested that the land should belong to its real cultivators and, if it is not possible and practicable, share-croppers should be given large size of holdings on contract for longer period of time.

Adequate and assured irrigational facilities also play decisive role in the adoption of agricultural innovations. It is, therefore, strongly suggested that the government should give top priority to develop irrigation facilities in its plan and policies in order to revitalize Indian agricultural technology. Various kinds of subsidies should be given to the farmers in various forms to develop medium and minor irrigation schemes. Besides this, farmers should also be educated about the proper and profitable use of water as most of them do not know ideal frequency of irrigation and optimum water requirements of the crop. Hence, the government should also encourage research on these lines so that farmers could apply irrigation water economically and cultivate their fields with the optimum use of water. Likewise the power also affects the adoption process. Hence, power generation should be accelerated to cope up with the increasing demand of power supply for both irrigation and other agricultural purposes. Similarly the supply of diesel for all agricultural purposes should be rationalised and the farmers should be assured of getting it when they need it. Both, the measures would have the way of speedy mechanisation of farm industry.

There is strong and positive relationship between the prompt availability of inputs and adoption of agricultural innovations. Therefore, in order to make the same available in time and in adequate quantity, various distribution centres should be open by the government and private agencies. Similarly proper arrangements must be made to give adequate and timely credit to the farmers whenever they require for it.

The study further showed strong and positive relationship between yield and adoption of agricultural innovations. The rate of adoption of such innovations helps to increase yield in much higher as compared to others. Hence, attempt should be made to introduce and propagate such improved practices, especially the new varieties of seed in research centres, which do meet these requirements

Needless to mention that if the farmers are assured of increased production and better gain, they will respond in large number to all the agricultural innovations.

Adequate and timely availability of subsidies also promotes adoption of agricultural innovations. Therefore, all kinds of incentives should be given to the farmers in the form of subsidies in cash or kind through various government and quasi-government agencies. Likewise, the surety of getting fair prices for agricultural production also promotes adoption of new higher practices. Hence, every attempt should be made to give higher prices to agricultural products through fair price shops, regulating markets, providing storage facilities. However, it is finally suggested that policy makers and social researchers should give much emphasis to economic variables.

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CHAPTER VII

SUMMARY AND SUGGESTIONS

SUMMARY AND SUGGESTIONS

Diffusion of Agricultural Innovations refers to the spread and implementation of new and improved agricultural practices over the existing one by the farmers in terms of use of HYV, pesticides, fungicides, herbicides, mechanisation agricultural farming etc The reflection of some innovation may be seen in behavioural form e.g., improved cultural practices. In other words we can say that diffusion of agricultural innovations means spread of adoption of improved agricultural practices. Diffusion of agricultural innovations has a very strong bearing upon the agricultural efficiency and productivity in any region or area. Diffusion of agricultural innovations do vary from one social system to another and also within the social system itself.

Hagerstrand (1952) was the first to demonstrate the idea of diffusion of agricultural innovations. He figured six components in the process of diffusion i.e., area, time, item, origin, destination and path. He derived a four-stage model to explain the innovation waves or more popularly called diffusion waves. These stages are; the primary stage, the diffusion stage, the condensing stage and the saturation stage.

The qualitative and quantitative techniques have been used for the present analysis of the study area:

The second degree and logistic curve have been used to analyse the trend of diffusion of agricultural innovations and coefficient of correlation has been used to examine the efficiency of the second degree curve and logistic curve. Weaver's minimum deviation method has been used to find out different crop combination regions. Kendall's ranking method has been used to analyse the various crops under different scale of performance over a period of time. For the determination of productivity the value is represented by converting the volume of produce of all the crops per unit of area into Rupees at current prices. To work out the trend of agricultural development trend line has been fitted the regression line. Further, the technique of composite Z score has been employed to determine the levels of diffusion of innovations and the correlation between the agricultural productivity and diffusion of agricultural innovations.

The Upper Ganga-Yamuna Doab is agriculturally developed region of Uttar Pradesh comprising of Saharanpur, Muzaffarnagar, Meerut, Ghaziabad and Bulandshahr districts. It is a monotonous and fairly productive plain of Western Uttar Pradesh. The region lies in between 28^0 4' to 30^0 24' east longitude and 77^0 2' to 78^0 29' east latitude According to 1991 census, it accounts of 14,243,132 population with a density of 690 persons per square km. Cultivation of crops has been the main occupation of the people in the region. The region has been the seat of Green Revolution and that is why it has been chosen the study area. The region is agriculturally prosperous, fertile and highly irrigated northwestern part of Uttar Pradesh.

An analysis of the agricultural development on the basis of techno-institutional advancement, trend of development of area, production and yield, regionalisation of agricultural productivity, crop combination and ranking of the crops reveal that there has been rise in area, production and yield. The rise in all three components is the main feature of post green revolution period. There has been a shift of area from coarse cereals to wheat, paddy and sugarcane. The production of these two crops grew rapidly with marked increase in yield level. However, the yield per hectare for all crops increased with the only exception of arhar, which indicates negative growth. It, therefore, implies the effect of area in the production and more pronouncing effect of new agricultural technology. The analysis of the production variability may be concluded that the infrastructure development of irrigation facilities is responsible for the adoptions of new package programs. The percentage of gross area increased from 34.89 to 73.69 percent in 1970-71 to 1993-94 respectively. About half of the irrigated area is shared by wheat followed by rice and sugarcane. Irrigation is necessary not only for the extension of the cultivated area but it also gives rise in the percentage share of area under double cropping. The means of irrigations have also changed tremendously from 1970-71 to 1992-93. The area under canal irrigation has declined from 42 to 26.98 percent in 1970-71 to 1992-93 respectively. While area irrigated by tubewell accounts for 43.60 percent, wells 13.65 percent and other sources 0.88 percent in 1970-71. In 1992-93 tubewells emerged to be the primary source contributing 70.87 percent of irrigated area. The share of canals, wells and other means declined to 26.98, 1.27 and 0.88 percent. The large scale introduction of electric pumps and oil engines are responsible for the increasing use of tubewells. This has consequently gave rise to the consumption of fertilizer during the same period. The total fertilizer used in 1970-71 in Upper Ganga-Yamuna Doab found to be 33.03 kg per hectare. Which increased to 142.98 kg per hectare in 1993-94. It further reveals that the consumption of fertilizers kg per hectare in Upper Ganga-Yamuna Doab has increased more than four hundred percent from 1970-71 to 1992-93. The percentage of area under high yielding variety of seeds occupied hundred percent of gross cropped area. The study area has also witnessed remarkable rise in the number of agricultural implements particularly tractors, oil engines and electric pumps.

The level of agricultural productivity improved mainly due to many fold increase in the modern agricultural implements and use of high yielding variety of seeds and fertilizers. At the same time, production fluctuated in the study area considerably due to inadequate rainfall and other environmental factors. The years of 1979-80, 1981-82, 1986-87, 1987-88, 1989-90 and 1991-92 have been, perhaps, the most difficult years when the output dropped significantly. This leads us to conclude that weather elements have still a bearing on the development of agriculture.

The study of trend of diffusion of agricultural innovations reveals that the farmers are now specialising in a few number of crops and devoting their most of arable land to one important crop in each of the rabi and kharif seasons. It is clear that subsistence traditional agriculture of the region is in the process of being transformed into market oriented semi-commercialised agriculture. Cultivators are not growing crops for family requirements but they have gone for the optimisation of their agricultural income. Infact increased agricultural income has improved and raised the standard of living of farmers, but at the same time many of the traditional institutions like that of mutual co-operations are being vanished. Consequently, large-size farmers have become more selfish and have increased their agricultural assets to significant extent. This trend has widen the gap of income in rural areas and had created many socio-economic problems.

It is quite obvious from the study that the process of diffusion of agricultural innovations was slow in the study area. But with the passage of time it has broken down and the rate of adoption increased slowly. In the latter half, the adoption process is very rapid. The diffusion process more or less follow the trend of second degree curve and it took a considerable time.

It is found that the process of diffusion of gross irrigated area and the fertilizer consumption follows the trend value of second degree curve. The trend lines of actual and second degree curve runs very close to each other since the beginning to an end where as the logistic curve shows the upward trend and becomes very close to the curve after 1988 and further follows the same trend line. The diffusion of gross irrigated area in Upper Ganga-Yamuna Doab as whole follows second degree curve which is in accordance with the findings of individual districts.

The study of level of diffusion of agricultural innovations on the basis of level of diffusion of irrigation, fertilizer and implements, composite z scores of the level of diffusion of innovations and correlation between agricultural productivity and diffusion of innovations revealed that the area under irrigation, consumption of fertilizer kg per hectare and the use of implements has steadily increased. It is attributed to the fact that this area has experienced the green revolution on a massive scale. The two variables such as irrigation and consumption of fertilizer are interdependent and co-terminus, meaning thereby the high doses consumption of fertilizer requires, assured irrigation for high productivity besides the high yielding variety of seeds, chemical fertilizer and assured irrigation to maximise the agricultural productivity. The high level of diffusion of innovations is due to the improved socio-economic conditions, literacy rate, exposure to mass media, social awareness, size of family, socio-economic status, size of land holding. Among all the factors irrigation has played dominant role in the increasing trend of consumption of fertilizers. Inhibition about the use of chemical fertilizer has been reduced due to increasing literacy rate in the region and therefore, the consumption of fertilizer has been in increasing trend.

The variations of level of diffusion of innovations is characterised by the variations in physico-cultural and socio-economic condition of the region, because it has direct bearing on the diffusion of agricultural innovations. The region which has adopted high level of diffusion of innovations is characterised by high irrigation, bigger size of land holding, high literacy, exposure to mass media, social awareness.

The relationship between agricultural productivity Rs. per hectare and diffusion of innovations in Upper Ganga-Yamuna Doab at tehsil level based on three year's moving average at the breaking point of time 1981–1986–1991, clearly reveals the positive correlation, though high rate of productivity and diffusion of innovations is observed in 1986 and followed by 1991. The reason behind the high rate of diffusion is the impact of green revolution and social awareness regarding the acceptance of innovations, but in 1991 the rate is not as much as in 1986, because the farmers are not only paying their attention towards the production of food grains but also towards the cash crops which are more remunerative.

Analysis of the impact of techno-institutional and socio-economic factors on diffusion of agricultural innovations revealed that techno-institutional and socio-economic factors have played significant role the process of diffusion of agricultural innovations. All the 12 factors considered in the present study have proved statistically significant and all have positive correlation with diffusion of agricultural innovations.

The Upper Ganga-Yamuna Doab is covered under the settlement scheme of consolidation of land, and in most of the sample villages this programme is almost over. But the size of land is still, by and large, is very small. The size of plots can be judged by the fact that about 63.63 percent of the holdings are less than one hectare. It is due to several reasons: firstly, the consolidation programme is not properly and rationally chalked out. There are several flaws in it. It is not properly implemented as well and the farmers are given more than one plots in the same type of land The farmers are harassed and they have to pay heavy prices for it. Secondly, farmers themselves prefer to have at least one plot in each soil type due to subsistence economy. Thirdly, the social tradition of Indian farmers to distribute the land among their sons and grandsons has further reduced the size of the plots.

With regard to tenurial status it has been proved that owner farmers have highest adoption index as compared to share-croppers. There are several reasons for this. The uncertainty in the duration of tenancy psychological feelings of detachment, small size of operational holdings and plots irrational and haphazard planning of cultivation are some of the important reasons. Adequate and assured irrigational facilities also play decisive role in the adoption of agricultural innovations. Likewise the power also affects the adoption process.

There is strong and power full relationship between the prompt availability of inputs and adoption of agricultural innovations. The study further showed strong and positive relationship between yield and adoption of agricultural innovations. The rate of adoption of such innovations helps to increases yield in much higher as compared to others.

Needless to mention that if the farmers are assured of increased production and better gain, they will respond in large number to all the agricultural innovations. Adequate and timely availability of subsidies also promotes adoption of agricultural innovations. Likewise, the surety of getting fair prices for agricultural production also promotes adoption of new higher practices.

SUGGESTIONS

In the light of above summery some suggestions have been made for the improvement in Diffusion of Agricultural Innovations, and planning for agricultural development and for future studies in the present area of investigation.

If the basic problem in planning is to narrow down the line lag between the introduction of an innovations and their wide spread of diffusion in the study area, we need to study more about various aspects of technological change and its spatial diffusion.

In order to increase the level of diffusion of agricultural innovations, it is suggested that medium and low level of diffusion region may be brought to the level of high diffusion of innovations provided the high level of irrigation, high literacy, exposure of mass media, availability of better marketing facilities, communication and transportation be made available to the respective region of the study area.

In order to enhance the impact of techno-institutional and socio-economic factor on diffusion of agricultural innovation following suggestions have been made:

(i) It is recommended that rational programme of consolidation should be implemented and legal restrictions should be imposed on fragmentation of holding. Besides this, attempt should also be made to consolidate the small holdings through co-operative and joint farming.

(ii) The land should belong to its real cultivators and, if it is not possible and practicable, share-croppers should be given large size of holdings on contract for longer period of time.

(iii) The government should give top priority to develop irrigation facilities in its plan and policies in order to revitalize Indian agricultural technology.

(iv) Various kinds of subsidies should be given to the farmers in various forms to develop medium and minor irrigation schemes.

(v) Farmers should also be educated about the proper and profitable use of water as most of them do not know ideal frequency of irrigation and optimum water requirements of the crop.

(vi) The government should also encourage research on these lines so that farmers could apply irrigation water economically and cultivate their fields with the optimum use of water.

(vii) Power generation should be accelerated to cope up with the increasing demand of power supply for both irrigation and other agricultural purposes.

(viii) The supply of diesel for all agricultural purposes should be rationalised and the farmers should be assured of getting it when they need it.

(ix) In order to make the agricultural inputs available in time and in adequate quantity, the government and private agencies should open various distribution centers.

(x) Proper arrangements must be made to give adequate and timely credit to the farmers whenever they require for it.

(xi) Attempt should be made to introduce and propagate such improved practices, especially the new varieties of seed in research centers, which do meet these requirements.

(xii) All kinds of incentives should be given to the farmers in the form of subsidies in cash or kind through various government and quasi-government agencies.

(xiii) Attempt should be made to give higher prices to agricultural products through fair price shops, regulating markets, providing storage facilities.

(xiv) It is finally suggested that policy makers and social researchers should give much emphasis to economic variables.

It may be concluded that present study is too brief to make any generalization either at global or at national level, but prediction could be made fairly at high degree of certainty in this connection for the entire geographical region with similar physico-cultural and socio-economic conditions.

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GLOSSARY

Local Names	English Names
Andhi	Dust Storm
Arhar	Pigeon Pea
Bhangar	Old alluvium
Bhur	Sandy soil
Boorhi	Old
Chikken	Clayey Soil
Doab	Land between two rivers
HYV	High Yielding Varieties
Jhil	Lake
Kankar	Calcium nodules
Khadar	New alluvium
Kharif	Rainy Season Crops
Kohra	Fog
Loo	Local hot wind prevent in summer
Misan	Dark Loam
Nadi	River
Nala	Seasonal Stream
Nildhara	Bluish nature of its water
Pargana	Administrative Sub-division of a tehsil
Pokhar	Pond
Rabi	Season of winter crops
Rahat	Persian Wheel
Raitily	Sandy
Rao	Seasonal River
Raunsli	Sandy Loam
Reh	Salt efflorescent
Seota	Clayey loam (Domat)
Tehsil	Administrative division of a district
Torrents	Streams
Usar	Saline-alkaline soil